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POLLUTION OF THE WATERS OF THE UPPER MISSISSIPPI RIVER AND ITS SIGNIFICANT TRIBUTARIES, MINNEAPOLIS-ST. PAUL METROPOLITAN AREA, MINNESOTA-WISCONSIN

J. M. Rademacher

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REPORT ON
POLLUTION OF THE WATERS OF THE
UPPER MISSISSIPPI RIVER AND
ITS SIGNIFICANT TRIBUTARIES
MINNEAPOLIS-ST. PAUL METROPOLITAN AREA

MINNESOTA - WISCONSIN

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REGION V
CHICAGO, ILLINOIS

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95

TABLE OF CONTENTS PAGE NO.

SUMMARY AND CONCLUSIONS 1

FOREWORD. 6

BACKGROUND. 7

THE AREA. 8

WATER USES. 11

- Municipal Water Supply 11
- Industrial and Commercial Water Supply 12
- Power - Steam and Hydro-electric Generation. 13
- Commercial Fishing 14
- Stock Watering and Irrigation. 15
- Navigation 16
- Fish and Wildlife Habitat. 16
- Wildfowl 17
- Recreation 18
  - Swimming and Water Skiing 19
  - Pleasure Boating. 19
  - Sports Fishing. 21
  - Water Oriented Parks and Aesthetics 22
- Waste Disposal 23

SOURCES OF WASTES 25

- Municipal Wastes 25
  - Federal Installations 26
  - Combined Sewer Overflows. 26
- Industrial Wastes. 27
- Thermal Sources. 29
- Commercial Barge and Pleasure Boat Traffic 30
- Agricultural 30
- Bulk Storage Areas, Pipelines, and Barges. 31
- Other Pollution Sources. 32

EFFECTS ON WATER QUALITY AND WATER USES 35

- Coliform Bacteria. 35
- 5-day Biochemical Oxygen Demand (BOD). 42
- Suspended Solids and Sludge Deposits 44
- Oil. 47
- Algae. 48
- Tastes and Odors 50
- Pesticides 52
- Temperature. 53
- Ammonia, pH, Alkalinity, Hardness, ABS 56

CONTROL ACTIVITIES OF STATE AGENCIES. 58

APPENDIX. 61

LIST OF TABLES

Table No.		Follows Page
1	Stream Flow Data	10
2	Steam and Hydro-electric Generating Plants . .	13
3	Fishing Licenses Issued.	22
4	Sources and Characteristics of Sewage.	25
5	Sewage Diversion Overfalls	27
6	Sources of Industrial Wastes	28
7	Industries Having Pollution Potential from Product Spillage, but Having No Direct Effluent Discharge.	31

LIST OF FIGURES

Figure No.		Follows Page
1	Twin Cities - Upper Mississippi River Area	60
2	Upper Mississippi River - Rum River to Minnesota River	10
3	Upper Mississippi River - Minnesota River to St.Croix River.	10
4	Upper Mississippi River - St.Croix River to Chippewa River.	10
5	Recreational Uses	19
6	Coliform Concentrations	41
7	Maximum Coliform Bacteria in a Single Drop of Water.	41

SUMMARY AND CONCLUSIONS

In summary, this examination of the one hundred and seven mile stretch of the Mississippi River extending from the junction with the Rum River above the Minneapolis-St. Paul Metropolitan Area downstream to the outlet of the interstate waters of Lake Pepin leads to two major conclusions:

1. Despite the efforts of the water pollution control agencies of Minnesota and Wisconsin and construction of waste treatment facilities by the Minneapolis-St. Paul Sanitary District, South St. Paul and other communities, the effects of pollution on this stretch of water are so great as to require remedial action;

2. Certain basic problems require further study. These problems range from an evaluation of all present important sources of wastes to a projection of the impact of future discharges upon the water resources of this area.

This section of the Mississippi and the near-by sections of the Minnesota and St. Croix Rivers are used for municipal and industrial water supply, navigation, power generation, pleasure boating, swimming, commercial and recreational fishing, and waste disposal.

Wastes discharged directly to the Mississippi include about 190 million gallons from treated municipal sources and at least another 20 million gallons from industrial process sources each day. The Minnesota River receives and delivers to the Mississippi about 24 million gallons of treated and untreated municipal and industrial wastes daily. Over three-quarters

of a billion gallons of river water each day are used for cooling purposes.

There are 29 municipal sewage treatment plants in the area serving a total population of more than 1 million persons. These plants discharge 200 million gallons of treated sewage each day. Almost all of the sewage is discharged from two plants - the Minneapolis-St. Paul Sanitary District and the City of South St. Paul.

Seventeen industries, processing a wide variety of products, discharge treated and untreated wastes directly to the Mississippi River. Principal constituents are oil, phenols, ammonia, oxygen-demanding materials, and suspended solids. In addition, twelve industries discharge wastes to the Minnesota River in the stretch from Mankato, Minnesota to the mouth. The discharge of all these wastes, both municipal and industrial, influences water quality.

Minnesota's basic guide for bathing or swimming waters requires as an upper limit an arithmetic average "most probable number" of 1,000 coliforms /100 ml during any one month of the recreational season, although this is subject to variance depending upon the results of a sanitary survey. The monthly average coliform counts for 1962 above St. Anthony Falls were 7,700 MPN/100 ml in July; 810,000 MPN/100 ml for September at Fort Snelling bridge above the Minnesota River; 43,000 MPN/100 ml in the Minnesota River during September, 1962; and six miles below the Minneapolis-St. Paul Sanitary District MSSD outfall coliform levels during August averaged 2,100,000 MPN/100 ml. High levels were also found in the interstate stretch of the Mississippi River below Prescott, Wisconsin and Hastings, Minnesota, at Diamond Bluff, and at Red Wing. Even at Frontenac, Minnesota on Lake Pepin

the average coliforms for the month of July, 1962 reached 9,100 MPN/100 ml. On the other hand the St. Croix River appeared to be in good condition based upon available bacteriological information. For most stretches of the Mississippi and Minnesota Rivers for which data are available, the coliform counts for intimate water contact sports always exceeded normally acceptable levels.

This excessive bacterial contamination presents a health hazard to recreational users on the Mississippi River from above St. Anthony Falls to Lake Pepin as well as to those who use the Minnesota River. Despite these health hazards, thousands of pleasure boaters and hundreds of water skiers use the waters of the Mississippi and Minnesota Rivers.

Raw sewage and surface run-off from almost eighty diversion structures on the combined sewage collection systems overflow at various times throughout the metropolitan area. They add to the hazard of bacterial contamination and produce visual nuisances on the surface of the water.

Oil from industrial sources and particularly from the recent accidental spills from storage facilities has killed thousands of ducks, fouled boats, and caused unsightly scum on the waters and beaches over wide areas. Most of the oil pollution results from oil leaks and spills with minimum amounts contributed by bilge pumpage from tow boats.

Fishermen, both sport and commercial, have been plagued on a continuing basis with tainted flesh in fish taken from the waters of the Mississippi River. The effects of phenols and other chemical constituents as well as algae on the production of taste and odors have yet to

be evaluated.

River bottom sludge banks extend 20 miles down the Mississippi River to the Hastings Dam with depths ranging up to 4½ feet. A high Bio-Chemical Oxygen Demand (BOD) from this and other sources has caused total depletion of oxygen in almost 7.5 miles of the river beginning a half mile below the MSSD plant. Noxious odors and floating sludge provide a noisome setting for any water user in the area. The replacement of desirable bottom life with pollution tolerant forms have been reported in a limited biological investigation. Feeding and spawning grounds for fish propagation are eliminated by the deposition of sludge.

The effect of water temperature is a water quality factor to be considered in the metropolitan area. Evaluations have been made on the relationship of water temperature to dissolved oxygen in terms of waste assimilation capacities of the Minnesota and Mississippi Rivers. The long term effects on the biota of the streams, however, as well as the more subtle effects on various chemical constituents of the river water have yet to be fully assessed.

Some of the problems requiring further study are evident.

* Studies of all important sources of waste should be undertaken so that the pollutional effects of each can be evaluated and acted upon.
* The specific industrial and other sources of wastes on the Minnesota River should be determined in like fashion.

* The overall effects of storm water overflows should be further evaluated.
* The effect of sludge deposits on bottom organisms which serve as a link in the fish food chain should be investigated further.
* The sources of all bacterial contamination of the Mississippi River should be identified. This should involve special quantitative studies of the possible fecal nature of the coliforms present.
* More thorough evaluation of the nutrient loads and impact on undesirable algae production should be made.
* The links between water quality and off taste in fish flesh should be identified.
* Finally, the projection of the impact of present and future waste sources upon the area water quality is a matter requiring high priority if area water resources are to be used to their maximum.

It is evident that pollution of the waters of the Mississippi River, and significant tributaries in Minnesota and Wisconsin within the Minneapolis-St. Paul Metropolitan Area and downstream into Lake Pepin, causes hazards to health or welfare of persons using these waters, and as such is subject to enforcement under provisions of the Federal Water Pollution Control Act (33 U.S.C. 466 et. seq.).

FOREWORD

This is a technical report on pollution problems on the Mississippi River in an area from the juncture of the Mississippi River with the Rum River above the Minneapolis-St. Paul metropolitan complex through the Lake Pepin outlet, one hundred and seven miles downstream. The significant tributaries to the Mississippi River, the Minnesota and St. Croix Rivers are included in view of their possible influence on Mississippi River water quality. The purpose of this report, which is based on available data obtained from State and local groups, is to examine and report on the uses made of the area's waters and on the existing sources of pollution.

The cooperation provided by these agencies, particularly the Minnesota Water Pollution Control Commission and the Wisconsin Committee on Water Pollution, in supplying the necessary information and in the review of drafts of the text for factual content should be recognized.

The report considers the quality characteristics of the water as they exist today, and evaluates the effects of waste discharges on water quality and water uses. The report contains conclusions thought to be justified on the basis of information presently available, and suggests areas in which additional investigations are needed.

BACKGROUND

In letters from Governor Karl A. Rolvaag of Minnesota and Governor John W. Reynolds of Wisconsin to Secretary Anthony J. Celebrezze of the Department of Health, Education, and Welfare on September 9, 1963, a request was made for action to abate pollution in the area as provided in the enforcement provisions of Section 8 of the Federal Water Pollution Control Act (33 U.S.C. 466 et. seq.).

In response to the request of the Governors, on September 23, 1963, Secretary Celebrezze sent letters calling for a conference in accordance with Section 8 of the Federal Water Pollution Control Act (33 U.S.C. 466 et. seq.) in the matter of pollution of the waters of the Mississippi River and its tributaries to official water pollution control agencies for the States of Minnesota and Wisconsin.

A formal public announcement of the conference and the initiation of a pollution study was made by the late President, John F. Kennedy, in a speech at Ashland, Wisconsin, on September 24, 1963.

Two major oil spills on the Minnesota River during the winter of 1962-63 resulted in the fouling of the Minnesota and Mississippi Rivers for a distance of over 100 miles and in the killing of several thousand ducks and other birds during the spring migration. Though these spills were recognized as accidental and extraordinary, they triggered an awareness of the overall pollution problems in the Mississippi River which work an economic hardship on the States of Minnesota and Wisconsin in terms of recreation and clean water for other purposes.

THE AREA

The States of Minnesota and Wisconsin are regarded as prime water playgrounds of the Middle West and the Nation. The Mississippi River has its origin in Minnesota and forms a common boundary between the two States as it wends its way to the Gulf of Mexico. This river is a natural present and future resource for both States.

The Conference Area, a very important segment of this river complex, extends from the mouth of the Rum River in Minnesota to the outlet of Lake Pepin. A distance of approximately 107 miles along the main stem of the Mississippi River is covered. The lower reaches of the Minnesota and St. Croix Rivers, which are tributary to the main stem, are also included within the Conference Area.

The Mississippi River within this reach has six slack water pools formed by dams across the River constructed for navigation and/or power purposes. With the completion of the St. Anthony Falls Lock in September, 1963 by the Corps of Engineers, navigation in a nine foot channel is possible through the entire metropolitan area. Physically, the Mississippi River is a study in contrast. Entering the Metropolitan Area the River drops rapidly with a 30 foot fall at Coon Rapids Dam, 75 feet more at the St. Anthony Falls in downtown Minneapolis, and another 38 feet at the Twin Cities Lock and Dam No. 1 some six miles further downstream. From this point the River drops only 20 feet in the remaining 88 miles to the outlet of Lake Pepin. Within this latter stretch the Minnesota

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River joins the main stem some nine miles below Lock and Dam No. 1 and the interstate St. Croix River combines with the Mississippi River about forty-one miles below the same dam to continue that common boundary between Wisconsin and Minnesota.

Lake Pepin covers the last twenty-two mile stretch of the River under consideration. Whereas the controlled backwater lakes formed by the dams at Red Wing and Hastings are relatively shallow, Lake Pepin has an average depth of 25 to 35 feet throughout its main portion. The lake's beauty rivals many other natural assets of the two States, which share it.

The uses of the particular stretch of the Upper Mississippi River described are governed by people and their activities. Twelve counties - nine in Minnesota and three in Wisconsin - have direct influences on the Mississippi River and its main tributaries, the Minnesota and St. Croix Rivers. All of these excepting Carver and Scott Counties in Minnesota and St. Croix County in Wisconsin border on the main stem of the Mississippi River.

On the basis of the 1960 Census, the population of these 12 counties was 1,634,328. Portions of or all of seven Minnesota Counties (Anoka, Hennepin, Ramsey, Washington, Dakota, Scott, and Carver) comprise the Minneapolis-St. Paul Metropolitan Area with a 1960 population of 1,525,297. The downriver areas are relatively sparsely populated in both Wisconsin and Minnesota. However, the picture for this entire area will be drastically changed if the estimates of the demographers and economists are

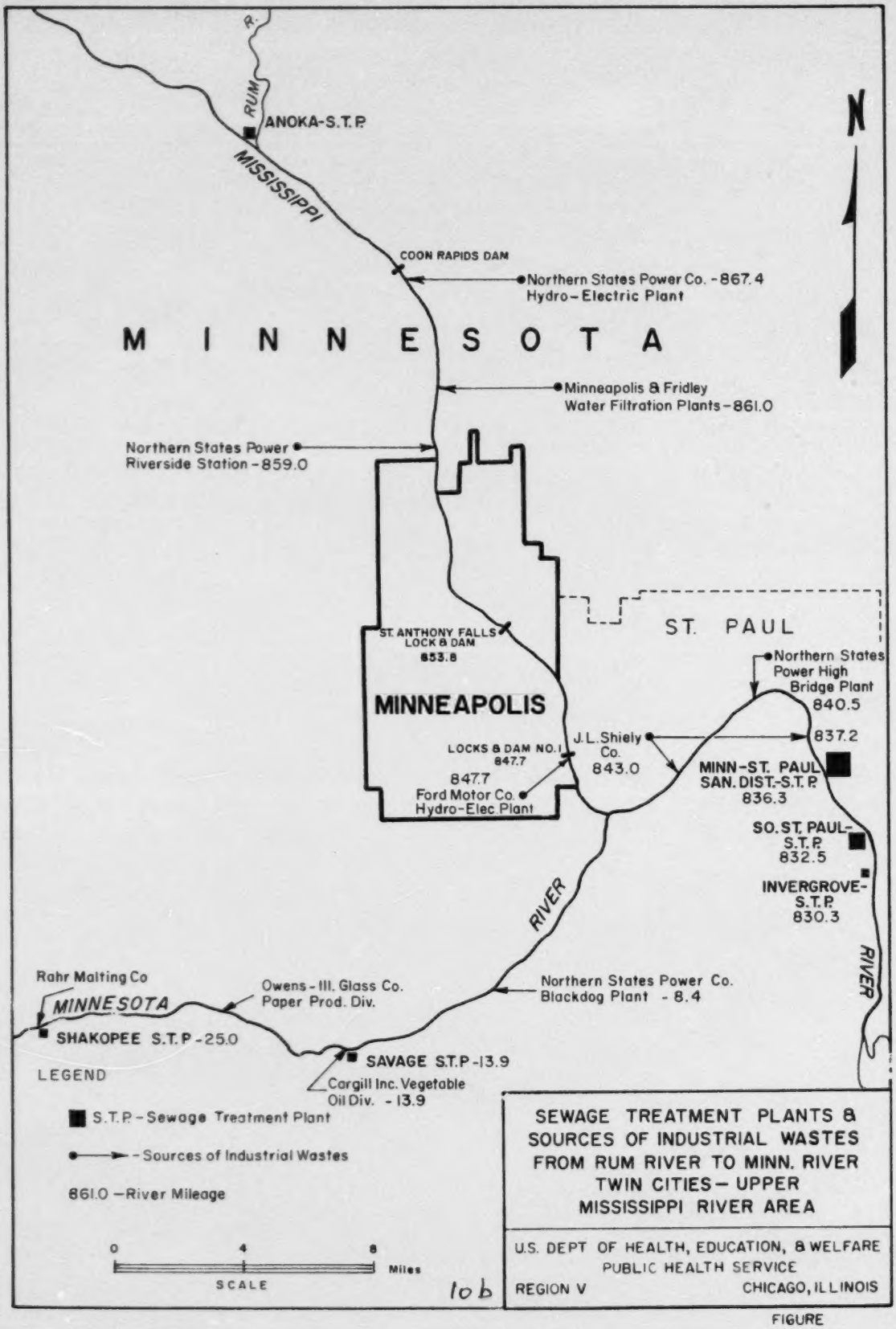
even approximated. They feel that this area will have almost three million people by the year 2000, if present trends continue. All these additional waste producers, with all their supporting commercial and industrial activities, will have available for use the River with no change in volume.

A wide variation in flows is experienced over the years by the Mississippi River. The following table prepared from information collected by the U. S. Geological Survey reflects the minimum, maximum, and average flow conditions in terms of cubic feet of water per second. The Mississippi River, as well as the St. Croix and Minnesota River, are to some extent affected by upstream storage reservoirs, from which water is released for such purposes as flood control, power and navigation.

TABLE 1

STREAM FLOW DATA IN CUBIC FEET PER SECOND

Location of Gaging Station	Year of Record	Average Flow	Maximum Flow	Minimum Flow
Coon Rapids Dam	28	6,903	75,900	586
St. Paul, Minnesota	61	9,832	125,000	632
Prescott, Wisconsin	31	14,810	155,000	1,380



SEWAGE TREATMENT PLANTS & SOURCES OF INDUSTRIAL WASTES FROM RUM RIVER TO MINN. RIVER TWIN CITIES – UPPER MISSISSIPPI RIVER AREA

U.S. DEPT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION V CHICAGO, ILLINOIS

FIGURE

SEWAGE TREATMENT PLANTS & SOURCES OF INDUSTRIAL WASTES FROM MINN. RIVER TO ST. CROIX RIVER TWIN CITIES – UPPER MISSISSIPPI RIVER AREA

U.S. DEPT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION V CHICAGO, ILLINOIS

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FIGURE 3

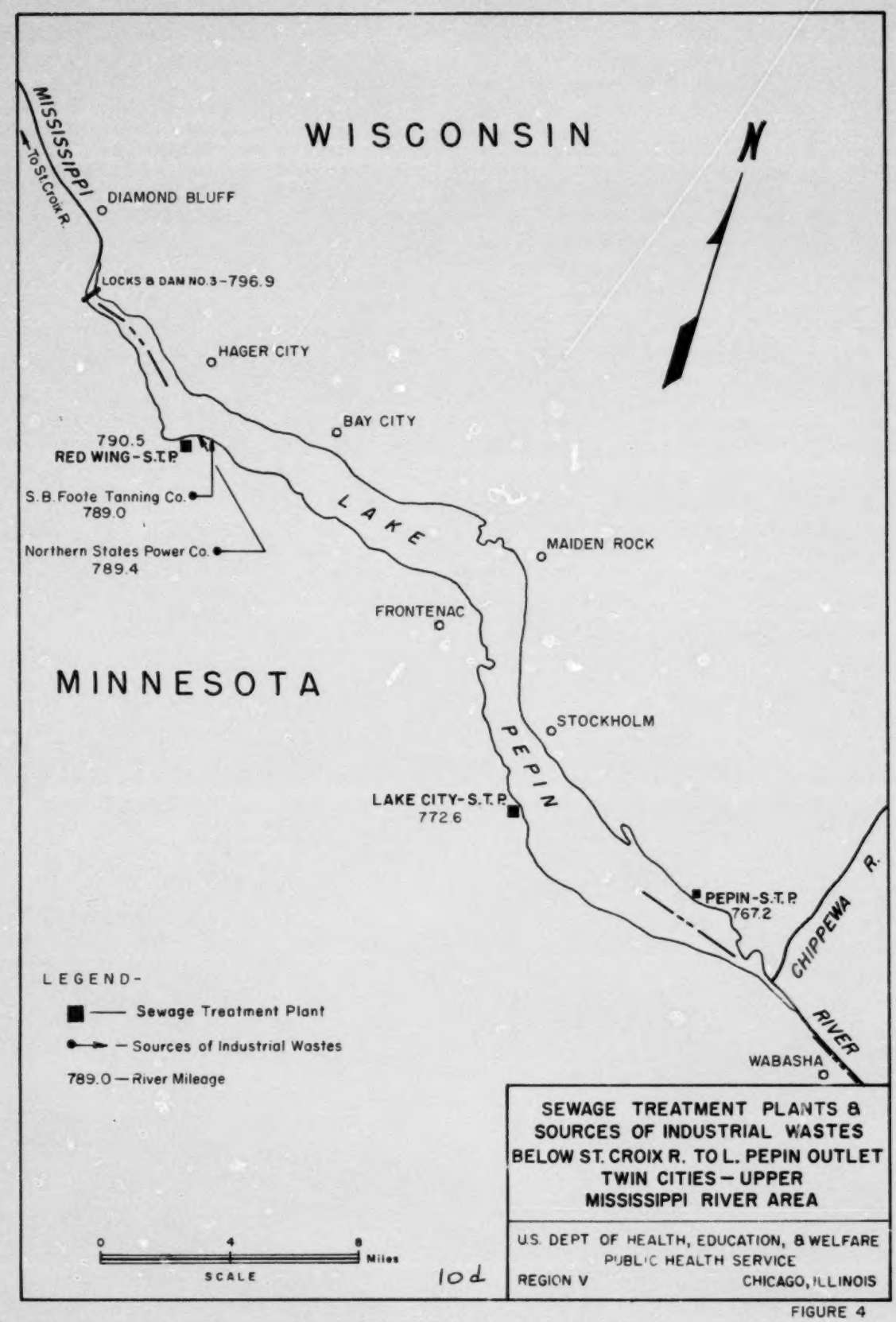

WISCONSIN
MINNESOTA
MISSISSIPPI
To St. Croix R.
DIAMOND BLUFF
LOCKS & DAM NO. 3 - 796.9
HAGER CITY
BAY CITY
790.5
RED WING - S.T.P.
S.B. Foote Tanning Co.
789.0
Northern States Power Co.
789.4
LAKE
MAIDEN ROCK
FRONTENAC
STOCKHOLM
PEPIN
LAKE CITY - S.T.P.
772.6
PEPIN - S.T.P.
767.2
CHIPPEWA R.
RIVER
WABASHA
LEGEND -
Sewage Treatment Plant
Sources of Industrial Wastes
789.0 — River Mileage
0
4
8
Miles
SCALE
10d
SEWAGE TREATMENT PLANTS & SOURCES OF INDUSTRIAL WASTES BELOW ST. CROIX R. TO L. PEPIN OUTLET TWIN CITIES — UPPER MISSISSIPPI RIVER AREA
U.S. DEPT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION V
CHICAGO, ILLINOIS

FIGURE 4

WATER USES

In any metropolitan area the proper disposal of sewage and industrial wastes is essential. Practical uses of water for public and industrial supplies, navigation, commercial fisheries, or stock watering are continuing necessities. In addition, the demands of today include such uses of water as fish and wildlife propagation, and water-oriented recreational activities. This latter use includes boating, water skiing, sport fishing, camping, swimming, picnicking, and aesthetics. In a State which offers as slogans "The Land of 10,000 Lakes" or "The Land of Sky-Blue Waters", the emphasis on water oriented recreation has great significance, particularly in the Minneapolis-St. Paul Metropolitan Area.

Municipal Water Supply

At this time the only use made of the Mississippi River system in this area for municipal water supply is in the upper reach of the river above St. Anthony Falls. However, it is of major significance, since the City of Minneapolis obtains all of its water from this source while the City of St. Paul obtains a major supplement from the river for its Vadnais Lake system. These systems supply a number of suburban users in addition to the principal cities. At the present time the annual average daily withdrawal from the River for the two cities is approximately 75 million gallons per day with an estimated maximum withdrawal during any one day reaching about 200 MGD. About 58% of the people living in the Metropolitan Area are served by the two supplies.

Future adequacy of supply for the Twin Cities is discussed in a publication of the Minnesota Department of Conservation, "Water Resources of the Minneapolis-St. Paul Metropolitan Area", Bulletin No. 11. In this report, the Department of Conservation estimates that by 1980 a minimum flow of 1,000 cfs in the Mississippi would not be able to meet the combined requirements for public water supply (est. 310 cfs average with a 620 cfs maximum), navigation (350 cfs required to operate the locks at St. Anthony Falls), the Riverside power plant (340 cfs) and hydro-electric power generation. Under these conditions of flow (1,000 cfs) and use, the hydro-electric power plants at St. Anthony Falls would not be able to operate.

The cities of Minneapolis and St. Paul have investigated supplemental sources of surface water supply and have concentrated on the St. Croix River and even Lake Superior as possibilities. With a variety of factors including suitable water quality to consider, the interstate stretch of the Mississippi River has not been a serious contender as a source of supply.

Industrial and Commercial Water Supply

The metropolitan area is supported by a variety of water-using industries including meat packing, brewing, paper products, petroleum refining, milling, mineral and rubber products industries, as well as chemical and allied products industries. Almost 70% of the water used by industry is ground water. Of the surface water used by industry over 99% is supplied by the Minneapolis and St. Paul municipal systems.

Over 126 MGD is used by industry in the Twin Cities area.

Power - Steam and Hydro-Electric Generation

Steam power plants on the Mississippi and Minnesota Rivers in the immediate area of the Twin Cities are the biggest users of water with almost four times the water use of the municipalities and industries combined. Almost 868 MGD was the average daily use by the two plants located on the Mississippi River and one plant on the Minnesota River in 1961, all of which is returned to the stream at a higher temperature. The capacity of each of these plants, in addition to power plants located at Mankato, Minnesota and Red Wing, Minnesota, are described in the following table. At this time only the Black Dog plant of the Northern States Power Co. has a cooling pond to reduce the thermal load on the Minnesota River and to serve as a reservoir during critical periods of low river flow.

An expansion of major proportions at the Riverside Plant is underway and is scheduled for completion in 1964. Within the next few years (1970) the first unit of a 1,000,000 KW plant will be built on the Mississippi River below the Minneapolis-St. Paul Sanitary District waste treatment plant. Initially, it will have a capacity of 500,000 KW. Known as the R. F. Pack plant, it will have a counterpart, the Prairie Island Plant, built in the succeeding decade at Red Wing, Minnesota. It also will have a capacity of 1,000,000 KW.

The hydro-electric power generation capacity is limited to the upper section of the Mississippi River above its juncture with the

TABLE 2

STEAM AND HYDRO-ELECTRIC GENERATING PLANTS

ON THE MISSISSIPPI AND MINNESOTA RIVERS

Twin Cities Area

NAME AND LOCATION	GENERATING * CAPACITY (KW)	MAXIMUM RIVER * INTAKE (MGD)
Steam Plants		
Mississippi River		
Riverside Plant	502,300 (1964)	490
High Bridge Plant	460,900	462
Red Wing Plant	25,000	54
Minnesota River		
Mankato Plant (Wilmarth Plant)	25,000	36
Black Dog Plant	260,000	396
Hydro-Electric Plants		
Coon Rapids Dam	8,240	4,200 MGD
Upper St. Anthony Falls(Main St. Plant)	960	2,600 MGD
Upper St. Anthony Falls(Hennepin Island Plant)	9,900	
Lower St. Anthony Falls	8,000	3,600 MGD
Ford Unit - Lock and Dam #1	13,930	3,880 MGD

* This information has been obtained from Bulletin No. 11 of the Minnesota State Department of Conservation, Division of Water. (MGD - million gallons per day)

** Data obtained from "Pollution and Recovery Characteristics of the Mississippi River", M.S.S.D. p. 167.

Minnesota River. The total hydro-electric generating capacity is only about 4% of the total steam power plant capacity in the area. With increased municipal and navigational demands for water above the Falls, operation of these hydro-electric units will be limited during low stream flows.

Commercial Fishing

Over the years millions of pounds of fish have been harvested by commercial fishermen on the Mississippi River. Complete records are available in the Annual Reports of the Upper Mississippi River Conservation Committee on size and variety of catches in all pools of the interstate sections of the river starting with Pool Number 3 above Red Wing, Minnesota.

Lake Pepin in Pool Number 4 has always been a major source of marketable fish. During 1961, for example, the total commercial catch for Pool 4 was 1,736,714 pounds valued at over $81,000. Pool 3, on the other hand, had a total commercial catch of 104,180 pounds valued at about $4,000. Carp is the predominant specie in the commercial catch and amounted to 94.5% of the total in Pool 3 and 93% in Pool 4.

Although specie variation and catch are influenced by such factors as canalization of the river, market demands and various other technical factors and needs involved in the commercial fishery operation, the quality of water also has a significant bearing on the matter. Along with other biological factors, the dominance of rough fish within a stream sector is used as one of the indicators of poor water quality by the

aquatic biologists. Carp are considered representative of the more pollution tolerant species of rough fish. Within the limitations cited, a general impression of the Mississippi River may be developed by comparing the ratio of carp to the total commercial catch during 1961 proceeding downstream on a pool by pool basis, as follows:

Pool 3 - 94.5%
Pool 4 - 93%
Pool 5&5a - 70%
Pool 6 - 60%
Pool 7 - 48%
Pool 8 - 53% (LaCrosse, Wisconsin located on this Pool)
Pool 9 - 50%

There is no commercial fishing in Pool 1. The Minnesota Department of Conservation reports that the average annual commercial catch for the 1959-62 period was 330,955 pounds in Pool 2.

In waters common to the States of Minnesota and Wisconsin in Pool 3 through Pool 8, 88% of the commercial catch was caught by Wisconsin fishermen and 12% by Minnesota commercial fishermen in 1961.

Stock Watering and Irrigation

Supplemental irrigation is practiced to a limited extent in the Twin Cities area. Most water for this purpose is obtained from wells for the estimated 4,000 acres that are under such control. Approximately 116 million gallons of water per year are used to increase production of agricultural crops in this manner, according to the Minnesota

Conservation Department.

Stock watering in the area is reported to use approximately 2 MGD. However, most stock raising activity is off the main stem of the Mississippi River except for an area in the vicinity of Hastings, Minnesota.

Navigation

The Twin Cities complex is the headwaters port for the Mississippi River and as such is a major marketing, distribution and transportation center. Barge traffic on the Mississippi and Minnesota Rivers, and to a minor degree on the St. Croix River, account for millions of tons of cargo shipped into and out of the area each year. Over 5 million tons of cargo were handled in the Ports of Minneapolis and St. Paul during 1963. With the completion of the 9 foot channel above St. Anthony Falls in September, 1963, and development of adequate docking facilities, the Corps of Engineers estimates that over 2,000,000 tons of cargo will be locked through the St. Anthony Falls Lock each year.

These vessels transport primarily petroleum products, coal, sand, gravel, grain and soybeans. The waterway has a normal operating season from late March to early December.

Fish and Wildlife Habitat

The Mississippi River is a prime source for a wide variety of fish. The type and preponderence of the fish population is in large part dictated by the habitat of the stream and its water quality. Factors such as stream depth, canalization, commercial traffic, weed growth, food sources, and spawning suitability affect habitat in general. Water quality includes

such factors as dissolved oxygen levels, temperature, turbidity, nutrient levels, as well as chemical concentrations.

The species of fish in the stretch of the Mississippi River under consideration range from game to rough. They include walleyed pike, northern pike, largemouth and smallmouth bass, panfish and a great variety of rough fish dominated by carp.

The bulk of the game fish are found in the St. Croix River, in Lake Pepin, in Pool 3 above Red Wing, and in the section above St. Anthony Falls. Carp, a rough fish, is reported to be a dominant specie in most sections. It is reported by the Minnesota Department of Conservation that on the basis of a 1956 survey, game fish in the Hastings Pool (L.&D. #2) were roughly half as abundant as in the Red Wing Pool (L.&D. #3).

Wildfowl

The Mississippi River is a major artery in the continental system of flyways serving the wildfowl migrations. Each year thousands of ducks, geese, and other migratory birds have made their annual trek to and from the north lands using the Mississippi River as a way station in their travels.

The State of Minnesota has recognized the importance of wildlife preservation in this area and has developed the 5,430 acre Gores - Pool Number 3 Game Refuge and Public Hunting Grounds some six miles southeast of Hastings.

Of incidental importance is the mammouth Upper Mississippi River Wildlife and Fish Refuge, which was developed by the Federal Government,

and extends some 284 miles immediately below the outlet of Lake Pepin. Although not in the area specifically under review, this major wildlife resource is dependent on good water quality. Like the State game refuge, it attracts many thousands of hunting enthusiasts from the metropolitan area. No precise figures are available of hunters or of birds bagged at these sporting resources located at the hunter's doorstep.

Recreation

The use of outdoor recreational facilities is growing rapidly in Minnesota and Wisconsin. With the number of camper days in the State parks increasing 600% in the last five years as an indication, recreation is the fourth largest industry in the State of Minnesota. A similar pattern has been set in Wisconsin with an increase from 158,000 camper days in 1957 to 847,000 in 1962. As an industry, recreation is in the top five for the State of Wisconsin. Both States are exerting efforts to keep pace with this growth.

In Wisconsin, the Outdoor Recreation Act of 1961 authorized a one cent tax on cigarettes for acquisition of lands for hunting, fishing, parks and other recreational purposes. $100,000 have been authorized for planning for recreational development within that State.

With this growth, in 1963 the Minnesota legislature passed an Omnibus Natural Resources Bill, designed both to enlarge economic opportunities and increase the citizen's enjoyment of his leisure time. A 1961 law allowing the use of a portion of unclaimed refundable State gasoline tax for the acquisition, improvement and maintenance of public access to the States' waters was an earlier step toward the development and expansion

of recreational facilities on the numerous waters of the State. The citizens of the Twin Cities metropolitan area consider these legislative actions as a method of expanding their recreational facilities from inland lakes to the great potential locations along such principal rivers as the Mississippi, Minnesota, and St. Croix.

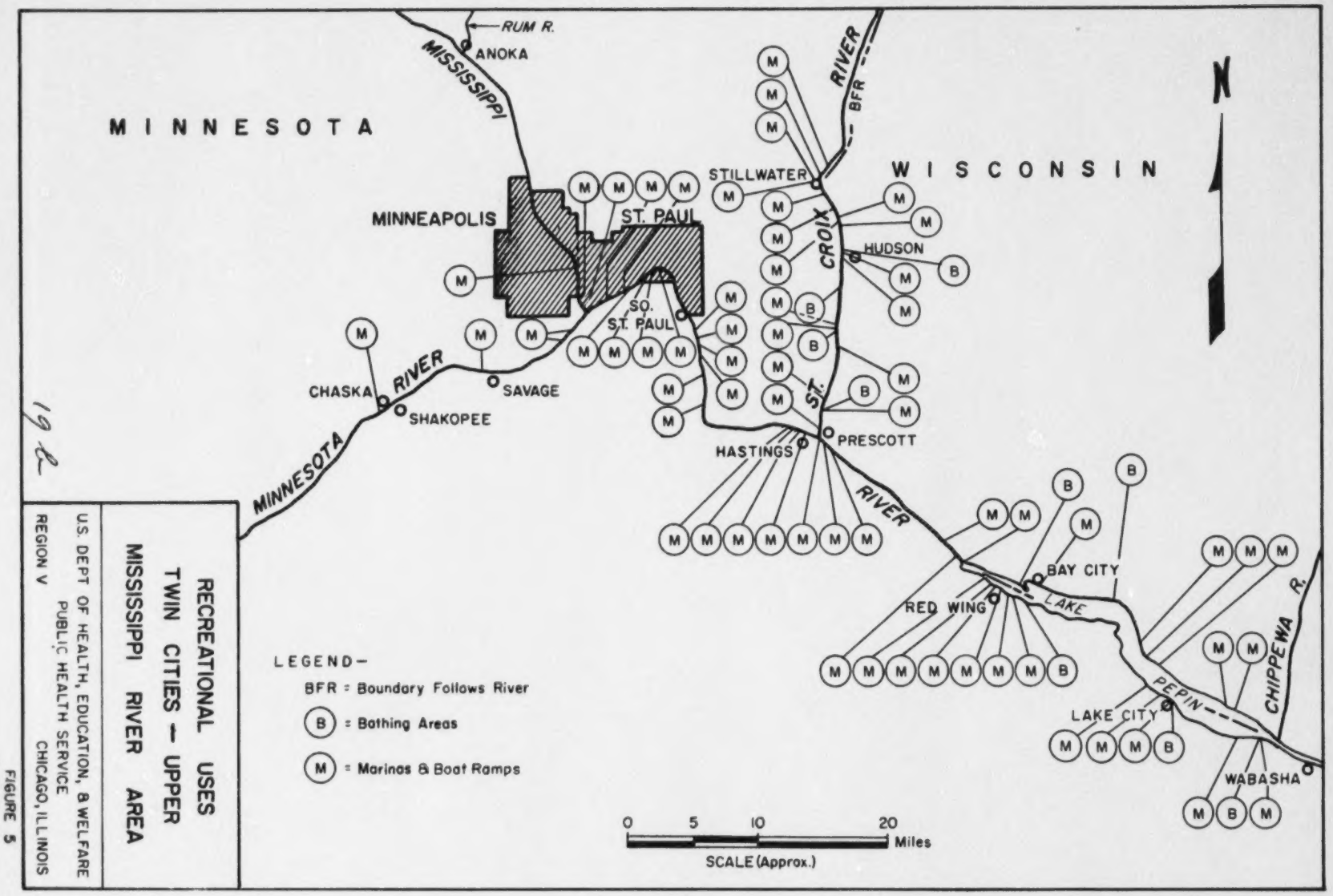
Swimming and Water Skiing

Swimming in the waters under consideration is almost totally confined to the St. Croix River and Lake Pepin. Lake Pepin has several fine beaches at Bay City, Wisconsin and Lake City, Minnesota as well as resort areas below Red Wing, Minnesota, and are regularly used by swimmers. No estimates of their number are available. The recreational use map indicates the locations of beaches in the area.

The increased horsepower available in today's marine outboard and inboard motors has given impetus to the sport of water skiing. It is particularly popular in the Twin Cities area of Minnesota and Wisconsin. The waters of Lake Pepin and the expanses of open water created by the back waters of the dams provide an ever increasing challenge to the water skier. Skiers have also used the Mississippi River below the Rum River for this particular sport.

Pleasure Boating

The popularity of pleasure boating in Wisconsin and Minnesota is great and can be measured in many ways. According to the Outdoor Boating Club, some 273,000 motors were in use in Minnesota and 232,000 motors in use in Wisconsin for a total of 505,000 as of December 31, 1963. In



19 L

RECREATIONAL USES
TWIN CITIES – UPPER
MISSISSIPPI RIVER AREA

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PUBLIC HEALTH SERVICE
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REGION V

FIGURE 5

Minneapolis-St. Paul alone approximately 131,000 motors were in use in this marketing area. Minneapolis is fifth among the nation's leading cities in outboard motor sales and motors in use. This represents a sizeable boon to the economy of the area, with millions of dollars invested in boats, motors, accessories, insurance, docking, storage, maintenance and repairs.

Pleasure boat marinas dot this waterway. The major concentrations are located on the St. Croix River, on the Mississippi River at Prescott, Wisconsin, at Hastings, and Red Wing, Minnesota, and at Lake City, Minnesota on Lake Pepin. Close into the Twin Cities, marinas have also been established on the Mississippi River below Lock and Dam #1. Both public and private launching ramps for trailered boats are sprinkled along the lower reaches of the Mississippi River in Pool 2 and 3 and Lake Pepin. A recreational use map shows that the St. Croix River has 13 marinas and 15 launching ramps. The Minnesota River has four marinas and 2 launching ramps. The Mississippi River below Lock and Dam #1 to the confluence with the Minnesota River has 3 marinas and 2 launching ramps. In the area from the entrance of the Minnesota River to Lock and Dam #2, at Hastings, 12 marinas and 8 launching ramps are located. From Lock and Dam #2 to Lock and Dam #3, above Red Wing, there are 7 marinas and 4 launching ramps primarily in the Hastings and Prescott area. In the much frequented stretch of the Mississippi from Lock and Dam #3 to the outlet of Lake Pepin, 19 marinas and 13 launching ramps are in use.

The Metropolitan Area of Minneapolis-St. Paul has hundreds of lakes

which receive intensive use and have their shores lined with homes. However, the needs have not been satisfied and pressures are constant for more recreational waters within easy access.

With the completion of the St. Anthony Falls Lock, the entire stretch of the Mississippi River to Coon Rapids Dam is accessible for boating. The Minnesota River is also navigable for pleasure boating for a distance of 25 miles to Shakpoee, Minnesota. The St. Croix is a prime area for recreational boating of all types.

The relative use of the pools can be gauged from lockage counts. In the report, "Pleasure boats through Locks - Mississippi River, St. Paul District", by the U.S. Army Engineer District, St. Paul, St. Paul Minnesota, the 1962 figures were for St. Anthony Falls Lock, 1 boat; for Lock #1, 959 boats; for Lock #2, 4,270 boats; for Lock #3, 4,501 boats; and for Lock #4, 3,943 boats.

Sports Fishing

Fishing is an important recreational activity in the Minneapolis-St. Paul to Lake Pepin area both in summer and winter. Studies on sport fishing conducted in areas similar to the Minneapolis-St. Paul area have shown as many as 75% of all available boats were used for fishing. On that basis, it appears that as many as 100,000 boats may be used for fishing in this area.

A further indication of sports fishing interest is the number of fishing licenses issued in the several counties included in the area. During the past year, the total number of persons using licenses was

374,420, or almost 23% of the resident population. A breakdown by county follows:

TABLE 3

FISHING LICENSES ISSUED IN

TWIN CITIES METROPOLITAN AREA

COUNTY	NO. OF PERSONS LICENSED *	COUNTY POPULATION
Anoka	24,717	85,962
Hennepin	195,170	842,854
Ramsey	74,125	422,525
Washington	34,960	52,432
Dakota	17,316	78,303
Goodhue	9,330	33,035
Wabasha	6,637	17,007
Minnesota Totals	362,255	1,532,118
St. Croix	6,670	29,164
Pierce	3,953	22,503
Pepin	1,542	7,332
Wisconsin Totals	12,165	58,999
Area Total	374,420	1,591,117

* This breakdown necessary because of the three classes of licenses issued by the State of Minnesota.

Ice fishing is also a popular sport along the river and on a typical winter day several hundred fishing shanties and anglers may be seen on the Mississippi River and Lake Pepin.

Water Oriented Parks and Aesthetics

The waters of the Upper Mississippi River are a focal point for parks and recreation areas.

Stillwater Park and Bayport City Park are located on the St. Croix

River. Along the Mississippi River are Hastings Park, Commissary Point picnic area, Colville Park, and Bay City Picnic Grounds. Frontenac State Park, located in Goodhue County, Minnesota, is the site of the State's first summer resort. Nearby is the famed Maiden Rock, in Wisconsin, a site that attracts many visitors.

William O'Brien State Park consists of 256 acres of wooded, rolling land fronting for almost a mile on the St. Croix River in Washington County. The Minnesota Conservation Department reports that a future State park will include part of Fort Snelling, Pike Island and adjacent parts of the Minnesota River valley. Part of the Crosby farm, located in St. Paul, along the left bank of the Mississippi River below Fort Snelling, may become a new city park.

Access to the Mississippi River above Lake Pepin to Prescott, Wisconsin, is somewhat restricted by the railroads which form iron bands binding the River on either side. However, the proposed development of the Great River Road should open this entire scenic stretch from Prescott, Wisconsin through Lake Pepin. An increasing demand for quality water to satisfy the developing recreational uses can be expected.

Waste Disposal

The waters of the area receive and carry away the sewage, industrial and other liquid wastes produced by the varied activities of the population. In the Twin Cities area waste disposal has become the dominant use below the MSSD outfall.

The Mississippi River in this area receives over a billion gallons

of waste water daily including sewage, industrial process water and cooling water. Wastes discharged directly to the Mississippi River include approximately 190 million gallons from municipal sources and at least another 20 million gallons of industrial wastes per day. The Minnesota River receives and delivers to the Mississippi River about 24 million gallons of municipal and industrial wastes daily. Over 900 MGD of cooling water were discharged from the area's power plants.

GPO 807-098-4

SOURCES OF WASTES

Municipal sewage, industrial wastes and heat are the principal pollutional materials discharged continuously into the waters of the Twin Cities area. Other wastes discharged intermittently may have serious local effects or may cause temporary excessive pollution. Among these wastes are accidental spills from storage tanks, barges, etc., combined sewer overflows, sewage from river front homes, wastes from barge tows and pleasure craft, and materials from dredging operations.

SEWAGE

The following table contains information on sources and characteristics of sewage discharged from various sources into the waters of the Twin Cities area.

MUNICIPAL WASTES

There are 29 sewage treatment plants in the area. Treatment provided ranges from primary to a complete secondary process followed by stabilization ponds. On the Mississippi River, all sewage treatment plants have provision for chlorination of effluents with the exception of Prescott, Wisconsin. Treatment facilities at Stillwater and Bayport, Minnesota, and Hudson, Wisconsin on the St. Croix River, have provision for chlorination. Of the municipal sewage treatment plants on the Minnesota River, all have chlorination facilities available except St. Peter, Le Sueur and Belle Plaine which use lagoons.

The treatment plants serve an estimated total population of 1,192,000. Of this population, the two major plants - the Minneapolis-St. Paul Sanitary District and South St. Paul - on the Mississippi River serve 89% of the total, or 1,061,000.

TABLE 4

Inventory of Municipal Waste

Source	Approx. River Mile	Pop. Equiv. Raw	Treatment	Est. Flow MGD	Type of System *	P.E. ** Disc. to Stream	Est. S.S. Disc. to Stream #'s/day
Rum River							
Nike Site #90	---	I.N.A.	2-CL	.010	I.N.A.	I.N.A.	I.N.A.
Mississippi River							
Anoka	871.6	15,000	2-CL	1.0	S	3,800	I.N.A.
Minneapolis, Combined sewer by-passes	---	Und.	None	Und.	C	Und.	Und.
St.Paul, Combined sewer by-passes	---	Und.	None	Und.	C	Und.	Und.
Minnesota River							
Mankato & N. Mankato, Minn.	101	42,900	1-CL	3.35	S-C	29,400	1,020E
St. Peter, Minn.	88	13,800	2-(lagoon)	0.900	C	1,380	146E
LeSueur, Minn.	73	5,000	2-(lagoon)	0.30	S	500	58E
Henderson	68	500	None	0.04	C	500	---
Belle Plaine	51	2,500	2-(lagoon)	0.15	S	250	39E

Source	Approx. River Mile	Pop. Equiv. Raw	Treatment	Est. Flow MGD	Type of System *	P.E. ** Disc. to Stream	Est. S.S. Disc. to Stream #'s/day
Chaska	29.8	6,000	2-CL	0.5	S	1,200	44E
Shakopee	25.0	3,400	1-CL	0.26	S	2,300	704E
Savage	13.9	2,900	2-CL	0.215	S	430	20E
Burnsville Twp.	---	5,000E	2-CL	.500E	S	500	98E
Cedar Grove Sub.Div.	---	1,300	2-CL	0.10	S	200	29E
96TC SQD.-Air Force	---	I.N.A.	1	.002E	I.N.A.	I.N.A.	I.N.A.
Total Minnesota River		83,300		6.317		36,660	2,158
Mississippi River							
Minneapolis-St.Paul San. Dist.	836.3	1,820,000	1-C-CL	178.1	C	1,250,000	122,000
South St.Paul Minneapolis	832.5	818,000	3-CL	8.72	C	162,000	4,700E
Newport	---	2,349	2-CL	0.25	S	U.C.	U.C.
Inver Grove Twp.	830.3	280	2-CL	0.02	S	42E	8E
St. Paul Pk.	829.6	2,500	2-CL	0.25	S	380	57E
Cottage Grove Twp.	819.6	6,000	2-CL	0.30	S	600	78E
Hastings	813.6	12,500	1-CL	0.500	S	8,000E	630E

Source	Approx. River Mile	Pop. Equiv. Raw	Treatment	Est. Flow MGD	Type of System *	P.E. ** Disc. to Stream	Est. S.S. Disc. to Stream #'s/day
Vermillion River							
Nike Site #40	---	I.N.A.	I.N.A.	.010	I.N.A.	I.N.A.	I.N.A.
Hastings State Hosp.	---	1,000	2-CL	0.09	S	100	24E
Mississippi River							
St. Croix River							
Stillwater, Minn.	23.0	8,300	1-CL	1.6	S-C	5,533	146E
Bayport, Minn.	20.0	4,000	2-CL	0.40	S	800	204E
Hudson, Wis.	16.4	4,110	2-CL	0.40	S	438E	78E
St. Croix Totals		16,410		2.40		6,771	428
Mississippi River							
Prescott, Wis.	811.0	1,350	1	.135	S	522E	106E
Red Wing, Minn.	790.5	10,530	2-CL	1.10	C	1,400	586E
Lake City, Minn.	772.6	3,600	1-CL	0.26	S	2,200	250E
Pepin, Wis.	767.2	825	1-CL	.027	S	102E	21E
Combined Totals of All Rivers		2,793,644		199.579		1,472,577	131,046

Treatment - 1 - Primary
2 - Secondary
3 - Secondary with tertiary lagoon
C - Chemical treatment
CL - Chlorination

I.N.A. - Inf. not available E - Estimated

* P.E. - Population Equivalent as measured by 5-day Biochemical Oxygen Demand

** Type of System - S-Separate
C-Combined

U.C. - Under Construction S.S. - Suspended Solids

A total of 200 million gallons per day of sewage is discharged to the area's waters by the 29 treatment plants. Of this, approximately 178 MGD or 89.3%, are discharged from the MSSD and South St. Paul plants.

Federal Installations

Detailed survey and evaluations of waste disposal practices at all Federal installations throughout the country are currently being made by the Public Health Service. The installations in the Twin Cities area are to be included in this program.

There are three Federal installations that reportedly discharge treated wastes to the surface waters of the Twin Cities area; the Nike site at Anoka, on the Rum River, the Nike site above Hastings on the Vermillion River, and the 96th TC Squadron Air Force facilities on the Minnesota near Wold-Chamberlain Field. These are included in Table 4.

Combined Sewer Overflows

Many of the older communities in this country have combined sewer systems. Both municipal sewage and surface run-off following rainfall are collected in the same system of sewers. The quantity of surface run-off frequently is many times that of the normal sewage flow. It is not economical to design sewage treatment plants with the capacities necessary to treat large quantities of run-off. Consequently, systems with combined sewers are designed to bypass portions of the combined sewage and surface run-off when the flows in the systems exceed the capacities of the sewage treatment plants. When overflow occurs, quantities of mixed raw sewage and surface run-off discharge through

bypass devices to nearby water courses. The Twin Cities area has a typically older, combined sewer system.

To avoid such raw sewage pollution of receiving waters most modern communities provide separate systems for collecting sewage and surface run-off.

There are many combined sewage overflows in the collecting systems in the Twin Cities area. The previous table includes information on the types of systems installed in the area. There are over 80 storm water overflow points reported in the Twin Cities area capable of discharging to the Mississippi River. The following table reflects the results of a sampling survey by the Minnesota Department of Health in 1960-61. The report included observations of overflows from diversion structures in the area. Some of these sewers discharge pollutional material on a more or less continuous basis while the majority discharge intermittently. (Table 5)

It is difficult to assess the pollutional effects of storm water overflows on receiving waters because there has not been sufficient study of either the characteristics of the overflows or of the effects on receiving waters during periods of overflow to develop factors that may be used in such evaluations.

Industrial Wastes

Industrial activity is concentrated almost completely in the Minnesota section of the area under consideration. The type and variety of the industries, as well as treatment provided, are listed in the following table, #6.

The table does not include data on sewage from plant employees. In many cases, the sewage is discharged to a nearby municipal sewer,

TABLE 5

SEWAGE DIVERSION OUTFALLS - TWIN CITIES AREA[1/]

Points of Overflow	River Miles Above Mouth	Nature of Wastes
Mississippi River		
Minneapolis & St.Paul, Minn.		
Broadway Street	855.5	Light flow of sewage and oil
Nicollet Island	854.5	Sewage
Bassetts Creek	854.0	Heavy flow
Lock & Dam (St.Anthony Falls)	853.8	
8th Avenue South	853.0	Oil Slick Discoloration
10th Avenue S.E.	853.1	Heavy flow (2.4 MGD est.) sewage, feathers coliform 3100 MPN/100 ml
4th Street South	853.0 (E.)	Light flow sewage, oil film
5th Street South	852.5	Heavy flow (2.4 MGD est.) coliform 170,000 MPN/100 ml
Bridal Veil Falls	851.5	Heavy flow (3.0 MGD est.) Clear - No odor. Coliform 780 MPN/100 ml
Franklin Street	851.3	Undet. - submerged outfall
Lake Street	849.8	Light flow - clear
38th Street	848.9	Sewage - coliform 16,000,000 MPN/100 ml
Lock & Dam No. 1	847.6	
Minnehaha (Large)	847.3	Light trickle
Minnehaha (Small)	847.3	Heavy sewage discharge (.3 MGD est.) coliform >24,000,000 MPN/100 ml

TABLE 5

SEWAGE DIVERSION OUTFALLS - TWIN CITIES AREA[1/]

Points of Overflow	River Miles Above Mouth	Nature of Wastes
Mississippi River		
Lock & Dam No. 1		
Eustice Avenue	849.8	Sewage and Industrial coliform 20,000 MPN/100 ml yellowish-brown color
Portland Avenue	849.2	Sewage (.4 MGD Est.) coliform 24,000,000 MPN/100 ml
Randolph Street W.	848.4	Sewage (0.4 MGD Est.) coliform 24,000,000 MPN/100 ml
Otto Avenue W.	847.8	Sewage (1.7 MGD Est.) coliform 5,400,000 MPN/100 ml
Minnesota River		
Mississippi River		
Davern Street	845.1	Sewage (0.2 MGD Est.) coliform 5,400,000 MPN/100 ml
Eagle Street	839.9	Sewage (0.4 MGD Est.) coliform 1,100,000 MPN/100 ml
Moses Street	839.9	Light flow (0.15 MGD Est.) coliform 780 MPN/100 ml
St.Peter Street	839.5	Sewage (0.15 MGD Est.) coliform 490,000 MPN/100 ml
Arthur Street		Light flow - sewage
Robie Street		Heavy sewage flow
Trout Brook at River	838.6	Sewage - cloudy - coliform 2,400,000 MPN/100 ml

1/ Observed during 1960-61 Survey - Minnesota State Department of Health

and is considered to be accounted for in the table on sources of sewage. In some cases, the industry or industries provide treatment plants for the plant sewage. In such cases, it is assumed that at least a majority of the plant employees live in surrounding sewered communities and likewise have been accounted for in the previous table on sources of sewage.

The table lists only those plants that discharge industrial wastes directly to nearby watercourses. Industries which discharge wastes to municipal sewerage systems are not included, since satisfactory disposal of these wastes is the responsibility of the municipalities involved.

The tabulation does not include information on the characteristics of the industrial wastes. Reliable recent data on volumes and constituents of many of the wastes were lacking.

Seventeen plants, which are listed on the main stem of the Mississippi River, discharge process wastes directly to the waters of the area. Principal waste constituents are oils, phenols, ammonia, oxygen demanding materials, and suspended solids. Most of the plants have some type of waste treatment or control but oil spills have occurred as the result of product handling and oil transfer operations from time to time. Metal fabricating wastes, including chromic acid, are discharged without treatment in the Hastings area.

Twelve industries discharge wastes to the Minnesota River between Mankato, and the Mississippi River Estimates on flow and specific waste constituents are not available. One food processing industry discharges wastes to the land through ridge and furrow irrigation.

Table 6
SOURCES OF INDUSTRIAL WASTES
MISSISSIPPI RIVER

Plant or Plant Division	Location	River Mile	Nature of Wastes	Waste Treatment or Control
Rum River				
Cornelius Mfg. Co.	Anoka County		Metal Fabricating	None
Federal Cartridge Co.	Anoka County		Metal Fabricating	U.N.D.
Mississippi River				
Minneapolis & Fridley Water Filtration Plants	42nd St. & Minn. Rt. 1 Fridley, Minn.	861.0	Water Treatment Plant Lime Sludge Discharge	Lagoons - Controlled Discharge
Northern States Power Riverside Station	Minneapolis, Minn.	859.0	Steam Power Generating Station Thermal Discharge	Ash Pond
Minnesota River				
Blue Cross Rendering Co.	Mankato, Minn.		Process & Condenser Water	Primary and Secondary
North Star Concrete Co.	Mankato, Minn.		Mfg. Gravel Washing	Tailings Basin Settling Basin
Archer Daniels Midland Co.	Mankato, Minn.		Tank Farm, Cooling Water	Oil Separation
Honeymead Products Co.	Mankato, Minn.		Vegetable Oil Processing	Oil Separator & Neutralization Tank
Northern States Power Co.	Mankato, Minn.		Condenser Water	None
Green Giant Company	LeSueur, Minn.	73	Food Processing	Fine Screens, and Ridge & Furrow Irrigation

Plant or Plant Division	Location	River Mile	Nature of Wastes	Waste Treatment or Control
Gopher State Silica, Inc.	Henderson, Minn.	68	Sand Washing	Clarification Basins
Minnesota Valley Milk Processing Coop. Assoc.	Belle Plaine, Minn.	51	Milk Drying	None
American Crystal Sugar Co.	Carver, Minn.	32	Beer, Sugar Processing and Refining	Lime Sludge Pond
Rahr Malting Company	Shakopee, Minn.	25	Grain Malting Operation	Screens
Owens-Illinois Glass Co. Paper Products Div.	Scott County, Minn.		Paper Box Mfg.	Extended Aeration
Cargill Inc., Vegetable Oil Div.	Savage, Minn.	13.9	Vegetable Oil Processing	Oil Separation
Northern States Power Co. Blackdog Plant & Dock	Dakota County	8.4	Condensing Water	Cooling Pond
Mississippi River				
J. L. Shiely Company		843	Sand and Gravel Washing Operation	None
Northern States Power Co. High Bridge Plant	High Bridge & Smith Ave., Minneapolis	840.5	Steam Power Generating Station	None
J. L. Shiely Company		837.2	Sand and Gravel Washing	None
Swift & Company	South St. Paul	833.4	Slaughtering and Meat Packing	To South St. Paul STP - Also submerged outfall to river
Armour & Company	South St. Paul	833.0	Slaughtering and Meat Packing	To South St. Paul STP - Also submerged outfall to river

Plant or Plant Division	Location	River Mile	Nature of Wastes	Waste Treatment or Control
Northwestern Refining Co.	Below Inver Grove	830.0	Petroleum Refining	API Separator, Sulfide Stripper, Tower Oxidation for Phenols, Oxidation Pond, Hay Filters
J. L. Shiely Company		827	Sand and Gravel Washing	Settling Basin
J. L. Shiely Company		825	Sand and Gravel Washing	None
General Dynamics Corp. Liquid Carbonics Div.	Pine Bend, Minn.	824.8	Liquid Carbon Dioxide	Cooling Water and process Chemicals treated by antagonism with nitrogen product wastes, St. Paul Ammonia Products, Inc.
St. Paul Ammonia Products, Inc.	Pine Bend, Minn.	824.8	Ammonia Systhesis and fertilizer Acids, oils chromates, nitratos and ammonia	Neutralization of acids, chromates, nitrates, and ammonia, plus oil separation
Great Northern Oil Company	Pine Bend, Minn.	824.0	Oil Refinery Raw Wastes including oil, phenols, sulfides, caustics, ammonia	API Separator, Lagoons, Hay Filter, Biofilter, Activated Sludge Unit, Sulfide Stripping, Chemical Neutralization of Caustics
Northwest Cooperative Mills, Inc.	Between Pine Bend and Hastings	823.5	Phosphoric Acid and Fertilizer prod.	Lagooning of Gypsum Sludge and Recycle
Minn. Mining & Mfg. Co. Chemolite Plant	Washington County above Hastings, Minn.	819.1	Chemicals	Primary Settling and Skimming also Lagooning for domestic sewage and and phenols - phenol removal undetermined

Plant or Plant Division	Location	River Mile	Nature of Wastes	Waste Treatment or Control
H. D. Hudson Mfg. Co.	Hastings, Minn.	814	Metal Fabricating Chromic Acid Wastes	Chemical Precipitation
Northern States Power Co.	Red Wing, Minn.	789.4	Steam Power Generation	None
S. B. Foot Tanning Co.	Outside Red Wing, Minn. at Hay Creek	789.0	Leather Tanning	Fine Screens Sedimentation and Lagoons

Thermal Sources

The prihcipal sources of thermal pollution at the present time in the study area are the Northern States Riverside, High Bridge and Black Dog power plants; The Northwestern Refining Co.; St. Paul Ammonia Products Inc.; Great Northern Oil Co.; Minneapolis-St. Paul Sanitary District plant, and the South Saint Paul sewage treatment plant.

Within the foreseeable future, thethermal load on the river will be increased with the addition of the proposed Northern States Power Plants at Red Rock and The Prairie Island Plant at Red Wing.

The latest figures available on thermal discharges are those for the months of January and August 1956 as presented in the MSSD report prepared by the Sanitary Engineering Division of the University of Minnesota. These figures are presented for the three Northern States Steam Power Plants and are as follows:

	Black Dog (Minn.River) Average MEga Btu/24hrs.	Riverside (Miss.River) Average Mega Btu/24hrs.	High Bridge (Miss.River) Average Mega Btu/24hrs.	Total Mega Btu Imput to Rivers for Avg. 24 Hr.Period
January	31,608	20,448	18,384	70,440
August	26,352	18,144	16,560	61,056

A new unit at the Riverside plant is being added this year which increases the generating capacity from 213,000 KW to 502,300 KW and which would modify the thermal output for this station in the above tabulation. With the exception of the thermal output at the Northwestern Refining Company which discharges up to 2.0 MGD of wastes with a temperature of 90° F. at times, the thermal outputs for the balance

of the industries and the MSSD are reported to have little effect on the heat balance in the Mississippi River during the critical summer months.

Commercial Barge and Pleasure Boat Traffic

Both commercial barge traffic and pleasure boats plying this river system have a potential for discharging wastes into the waters of the area. An estimate of the magnitude of discharge would be difficult to assess.

An indication of the potential loading to the river might be gained by examining the amount of traffic passing through a specific lock at one of the Corps of Engineers' dams. For example, in 1962 at Lock and Dam #2 at Hastings, 1,325 commercial lockages and 2,184 pleasure boat lockages, with a total of 4,270 craft, were reported. With an estimated average crew of 6 to 10 on a commercial tow and an average occupancy of 3 per pleasure craft, the total through the lock may have ranged up to 20,000 persons during the navigation season.

Although pollutional discharges from this source are generally distributed over wide areas, localized effects cannot be discounted particularly in the marina and terminal areas. The sewage, combined with other discharges such as bilge pumpages, garbage and litter present an increasing problem.

Agricultural

The waters of the Mississippi River within the area covered by this report are bordered by approximately 200 miles of shore line, much of which is devoted to parks, forests, and improved agricultural lands.

Steep bluffs are a predominant feature of this area, conducive to high rates of run-off which may conceivably contain fractions of the 55,000 pesticide products currently registered with the Federal Government. Tentative studies have been initiated in the summer of 1963 by the Minnesota Water Pollution Control Commission to investigate this problem in the surface waters in Minnesota.

In addition to the above possibility, the improved farm lands are a potential source of the nutrients being contributed to the waters. No work is in evidence relative to the extent of sources or effects of nutrient levels within the area.

Bulk Storage Areas, Pipelines & Barges

One good that results from accidental losses of valuable commodities is the public awareness and concern it creates. Major oil spills on the Minnesota River in the winter of 1962 were of paramount importance in the recent delegation of authority to the Minnesota Water Pollution Control Commission by the 1963 legislature to prohibit storage without proper safeguards of any liquids which could cause pollution of waters (Sec. 5, Subd. 3(2) of Laws of 1963, Chapter 874).

While above-ground storage facilities create a potential hazard to nearby water courses, they are by no means the only potential problem. Throughout the country in recent times such disasters as the sinking of barges containing items from chlorine to rye have occurred; oil transfer lines have ruptured during unloading operations; and heating coils within tanks have separated causing damaging substances to be discharged to the watercourse. These are all items which can have far-reaching effects

TABLE 7

INDUSTRIES HAVING POLLUTION POTENTIAL FROM PRODUCT SPILLAGE, BUT HAVING NO DIRECT EFFLUENT DISCHARGE

PLANT OR PLANT DIVISION	LOCATION	RIVER MILE
Mississippi River		
Western Oil & Fuel Company Terminal	Minneapolis	852.9
Municipal Coal Terminal	Minneapolis	852.8
Pure Oil Company Terminal	Minneapolis	852.7
Municipal Barge Terminal	Minneapolis	852.5
Phillips Petroleum Company Terminal	Minneapolis	852.4
Great Northern Oil Company	Minneapolis	852.0
The Texas Company Terminal	St. Paul	842.5
Socony Mobil Oil Company Terminal	St. Paul	842.3
Shell Oil Company Terminal	St. Paul	842.2
Archer Daniels Midland Terminal Company Terminal	St. Paul	841.7
Petco Oil Company Terminal	St. Paul	841.6
Clark Oil Company Terminal	St. Paul	841.5
Northern States Power Company Coal Terminal	St. Paul	840.5
Minnesota Harbor Service Barge Cleaning Facility	St. Paul	840.4
W. H. Barber Company Terminal	St. Paul	840.3

GPO 807-096-5

PLANT OR PLANT DIVISION	LOCATION	RIVER MILE
St. Paul Grain Terminal	St. Paul	840.0
American Mineral Spirits Company Terminal	St. Paul	839.4
Fluid Storage Inc. Terminal	St. Paul	837.4
Walsh Grain Company Terminal	St. Paul	837.4
Municipal Barge Terminal	St. Paul	837.3
Continental Grain Company Terminal	St. Paul	836.9
Northwest Refining Company Terminal	St. Paul Park	830.0
Northwest Refining Company Terminal	Hastings, Minn.	814.6
Hermanson Coal Dock	Prescott, Wis.	811.0
Municipal Barge Terminal	Red Wing, Minn.	791.2
Central Soya Terminal	Red Wing, Minn.	791.0
Northern States Power Company Coal Terminal	Red Wing, Minn.	789.4
Minnesota River		
Continental Grain Terminal Co.	Between Savage & Minneapolis	14.7
Central Soya Company Terminal	Between Savage & Minneapolis	14.6
Richards Oil Company Terminal	Savage, Minn.	14.5
(Port) Cargill Inc. Terminal	Savage, Minn.	13.9
Northern States Power Company Blackdog Plant Coal Dock	Minneapolis	8.4
Barge Cleaning Facilities	Minneapolis	8.0

PLANT OR PLANT DIVISION	LOCATION	RIVER MILE
St. Paul Grain Terminal	St. Paul	840.0
American Mineral Spirits Company Terminal	St. Paul	839.4
Fluid Storage Inc. Terminal	St. Paul	837.4
Walsh Grain Company Terminal	St. Paul	837.4
Municipal Barge Terminal	St. Paul	837.3
Continental Grain Company Terminal	St. Paul	836.9
Northwest Refining Company Terminal	St. Paul Park	830.0
Northwest Refining Company Terminal	Hastings, Minn.	814.6
Hermanson Coal Dock	Prescott, Wis.	811.0
Municipal Barge Terminal	Red Wing, Minn.	791.2
Central Soya Terminal	Red Wing, Minn.	791.0
Northern States Power Company Coal Terminal	Red Wing, Minn.	789.4
Minnesota River		
Continental Grain Terminal Co.	Between Savage & Minneapolis	14.7
Central Soya Company Terminal	Between Savage & Minneapolis	14.6
Richards Oil Company Terminal	Savage, Minn.	14.5
(Port) Cargill Inc. Terminal	Savage, Minn.	13.9
Northern States Power Company Blackdog Plant Coal Dock	Minneapolis	8.4
Barge Cleaning Facilities	Minneapolis	8.0

and for which control is difficult. Another problem is the inadequate diking of waste lagoons adjacent to water courses subject to periodic flooding.

Within the area described here, there exist some 33 barge terminals and barge cleaning operations and bulk storage facilities. To this potential must be added the possible hazard generated by the hundreds of tons of gasoline and other petroleum products transported by barges during the year. The Corps of Engineers estimate that possibly 5% of the barges in this traffic would develop as "leakers."

Other Pollution Sources

In addition to the major rivers within the area covered by this report, there are at least 15 small tributary streams contributing to the overall water quality picture. Slight as these sources seem, it must be realized that some of these small watersheds incorporate industrial and urban areas while others accept drainage from cultivated farm lands, small settlements and individual homesites.

Data has been obtained on some of these tributaries relative to the total coliform densities, D.O., and B.O.D. These data have been obtained by the Minnesota Department of Health prior to 1962 with more detailed studies being currently performed. Some of those tributaries and pertinent data are as follows:

Rum River: All of the sources of direct discharge of raw sewage have provided or are making progress toward construction of treatment facilities. Total coliform densities averaged 3,800 MPN/100 ml for the 44 determinations made.

Cook Creek: This creek drains a mainly flat, sandy agricultural land which is sparsely populated except for the southern part southeast of Anoka which contains extensive suburban residential areas. Samples collected since 1960 indicate high D.O., low B.O.D. and a total coliform average of 6060 MPN/100 ml for 13 determinations.

Rice Creek: This stream drains the area northeast of Fridley and at present receives no discharge from a public sewerage system. However, some treated industrial wastes do enter the Creek. Thirteen determinations show a high average D.O., a B.O.D. of 7.4 mg/l and a coliform average density of 3,425 MPN/100 ml.

Shingle Creek: This Creek drains a mainly rural area northwest of north Minneapolis. There are at present no major waste-producing indistries in the area nor are there any surface discharges from municipal sewerage systems. Eleven determinations indicate average values of 9.7 mg/l for D.O., 4.2 mg/l for B.O.D. and total coliform average density of 509,800 MPN/100 ml.

Bassetts Creek: This Creek drains an area west of Minneapolis largely devoted to residential development and farming. The Creek is considered potentially valuable for recreational use because of growing residential areas near it. Thirteen samples taken one mile above

the mouth show averages of 866,900 MPN/100 ml for coliforms, a D.O. average of 6.6 mg/l, and B.O.D. of 12.7 mg/l.

Minnehaha Creek: This stream serves as the outlet of Lake Minnetonka and also drains an extensive area between the outlet of the lake and the Mississippi River. Eight determinations indicate a coliform group average of 22,400 MPN/100 ml, with a D.O. of 9.0 mg/l and a B.O.D. of 5.1 mg/l.

Within the Minneapolis-St. Paul metropolitan area itself, an estimated 342,000 people are at present dependent on individual home sewage disposal facilities, consisting primarily of a septic tank with a subsurface drain tile field or cesspool for disposal of the tank effluent. The great number of these installations in close proximity to one another are a threat to the quality of the underground waters.

In addition, many commercial establishments, suburban shopping places, trailer camps, motels, restaurants, etc. are located throughout the area and many discharge treated and untreated wastes into the water courses leading to the Mississippi and Minnesota Rivers. The effect on the bacteriological quality in particular should be considered as having significance.

The U. S. Army Corps of Engineers in maintaining channel depths in the Mississippi and Minnesota Rivers have established a year around program of dredging and spoil deposition. This program is of two types, deposition by hydraulic methods in spoil areas along the shore and by barges to downstream off-channel areas.

EFFECTS ON WATER QUALITY AND WATER USES

With knowledge of the sources of wastes in the conference area as well as information on such water quality indices as coliform bacteria, BOD, dissolved oxygen, pH, temperature, suspended solids, etc., an assessment may be made of the effects on the existing and potential uses of the waters in the area. The following section outlines these effects insofar as information is available for a reasonable evaluation.

COLIFORM BACTERIA

Minnesota's basic guide for bathing or swimming waters has a limiting value for coliform density although this may vary depending upon the results of a sanitary survey. The upper limit is a "most probable number" of 1,000 coliforms per 100 ml as determined by the arithmetic average of coliform counts during any one month of the recreation season.

According to many State and interstate pollution control agencies, waters used for swimming and water contact sports should not average more than 1,000 MPN/100 ml total coliform bacteria and those used for general recreation should not average more than 5,000 MPN/100 ml.

For example, the Ohio River Valley Water Sanitation Commission, representing eight States, and the Engineering Section of the Missouri Basin Health Council, representing ten States, have adopted the following guide:

> "For bathing or swimming waters, monthly arithmetical average 'most probable number' of coliform organisms should not exceed 1,000 per 100 ml during any month of the recreation season; nor exceed this number in more than 20 percent of the samples examined during any such month; nor exceed 2,400 per 100 ml on any day. For non-bathing or non-swimming waters, the monthly arithmetical average 'most probable number' of coliform organisms should not exceed 5,000 per 100 ml in any month of the recreational season, nor should exceed this number in more that 20 percent of the samples examined during any such month."

In this report, coliform concentration data, supplied by the Minneapolis-St. Paul Sanitary District for 1962, were used. The information was reported in terms of coliforms per cubic centimeter, using the presumptive test only. Since most standards for quality with respect to this indice are reported in terms of coliforms per 100 ml, the data was adjusted to this format.

In the Mississippi River above the Minnesota River, the monthly arithmetical average coliform levels near the intake for the Minneapolis Water Plant (River Mile 858.5) ranged from 1,100 in December to 13,000 coliforms/100 ml in May. The high individual count was reported as 22,000 coliforms/100 ml and occurred on May 24. At the Fort Snelling Bridge (River Mile 845.5) the monthly average coliform concentrations ranged from 7,000 coliforms/100 ml for June to 810,000 coliforms/100 ml in September. The high individual count was reported as 1,600,000 coliforms/100 ml on September 19. The high coliform levels in this upper stretch of the Mississippi River may be attributed to storm water overflow contributions, land run-off, and contributions from such tributaries as Minnehaha Creek, Bassetts Creek, Shingle Creek, and Rice Creek.

The Minnesota River (River Mile 845.4) at its mouth had a monthly average range of 940 coliforms/100 ml in February to 43,000 coliforms per 100 ml in September with an individual high of 79,000 coliforms per 100 ml reported on September 6, 1962. Downriver, immediately above the MSSD plant outfall, the monthly average coliform levels ranged from 11,000 coliforms/100 ml in June to 62,000 coliforms/100 ml in August. The individual high during the recreation season was 160,000 coliforms per 100 ml. Again, the relatively high levels may be attributed to the effects of the metropolitan complex through which the river passes.

Below the MSSD outfall the sampling station data describes the very high coliform levels contributed by that source and the South St. Paul Treatment Plant. At the Inver Grove Bridge (River Mile 830.3) some six miles below the MSSD plant and two miles below the South St. Paul Plant the monthly average coliform levels ranged from 100,000 coliforms per 100 ml in April to 2,800,000 coliforms/100 ml in October with an individual high of 4,900,000 coliforms/100 ml on September 26. Almost eight miles further downstream at Grey Cloud Landing (River Mile 822.5) the monthly average coliform levels ranged from 110,000 coliforms/100 ml in January to 1,700,000 coliforms/100 ml for August with a high of 3,500,000 coliforms/100 ml reported during May. Between June and October the individual high was 2,400,000 coliforms/100 ml on August 23. At the Hastings Highway Bridge (River Mile 813.9) the coliform range was 12,000 coliforms/100 ml in March to 560,000 coliforms/100 ml in July and August. The individual high at this station was 2,400,000 coliforms/100 ml

on August 1. The coliform levels in this stretch of the river reflect the heavy input at the two major sewage treatment plants and the "die-away" rate to Hastings. The St. Croix River appears to be in good condition on the basis of coliform levels. The monthly average coliform concentrations for this river ranged from 100 coliforms/100 ml in October to 620 coliforms/100 ml during June. The individual high reported was 1,700 coliforms/100 ml on July 10, 1962.

In the interstate reach of the Mississippi River below Hastings, Minnesota and Prescott, Wisconsin, significant levels of coliform concentrations are reported. At Prescott Island (River Mile 810.2) the monthly average range was 22,000 coliforms/100 ml in October to 360,000 coliforms/100 ml in August with an individual high of 920,000 coliforms per 100 ml reported in August. At Diamond Bluff (River Mile 800.5) the monthly average range was 4,900 coliforms/100 ml in March to 160,000 coliforms/100 ml in July with a high of 350,000 coliforms/100 ml reported on June 20. Above Lock and Dam No. 3 (River Mile 796.9) the monthly average range reported was 5,200 coliforms/100 ml for March to 63,000 coliforms/100 ml for the months of November and December. The individual high occurred during December and was reported at 130,000 coliforms/100 ml. During the summer months the monthly average range was 21,000 to 36,000 coliforms/100 ml with only one sample having a count less than 5,000 coliforms/100 ml (4,900/100 ml).

Continuing downstream, at Red Wing, Minnesota (River Mile 792.0) the monthly average coliform range was 3,200 coliforms/100 ml for

February to 64,000 coliforms/100 ml for November. The high point was reached on both August 14, and November 14 at 79,000 coliforms/100 ml.

In Lake Pepin the monthly average coliform concentrations at Frontenac (River Mile 779.0) ranged from 490 coliforms/100 ml (one sample) for March to 14,000 coliforms/100 ml in November (high individual sample - 24,000 coliforms/100 ml on November 14). High counts of 13,000 and 14,000 coliforms/100 ml were recorded during July of this period. Opposite Lake City, Minnesota, (River Mile 772.8) the range was 170 coliforms/100 ml for March (one sample) and 7,200 coliforms/100 ml for November. The high individual count was 11,000 coliforms/100 ml on November 14. All nine samples collected during the summer months of June through September, 1962, had coliform densities less than 5,000 coliforms/100 ml and six of the nine had densities greater than 1,000 MPN/100 ml. At the outlet to Lake Pepin (River Mile 764.9) the range of coliforms reflected relatively clean water with concentrations reported at 45 coliforms/100 ml in December and 1,000 coliforms/100 ml in November. The high individual count occurred in November at 1,300 coliforms/100 ml.

It appears from the collected data for 1962 and other years that high concentration of coliform bacteria are present in the interstate reach of the Mississippi River and in Lake Pepin, although the bacterial quality at the Lake's outlet is good. A pictorial representation (Figure 6) relates the maximum coliform levels to the standards for swimming and other recreational uses as described earlier. Using a maximum value of 1,600,000 coliforms/100 ml in the stretch of the Mississippi River above

its juncture with the Minnesota River, anyone ingesting a single drop of water with this bacterial density would swallow about 800 sewage bacteria. At the station above the MSSD outfall, each drop would have 80 sewage bacteria during the maximum concentration of 160,000 coliforms per 100 ml. Below the MSSD plant at Grey Cloud landing each drop swallowed could contain as many as 1,750 sewage bacteria. In the interstate section of the river with counts as high as 130,000 coliforms/100 ml at Lock and Dam No. 3, 97,000 coliforms/100 ml at Red Wing and 24,000 at Frontenac, each drop of water sprayed into a boaters mouth or swallowed by a swimmer or water skier would have the possibility of 65, 39, and 12 sewage bacteria being ingested, respectively. Figure 7 reflects these possibilities.

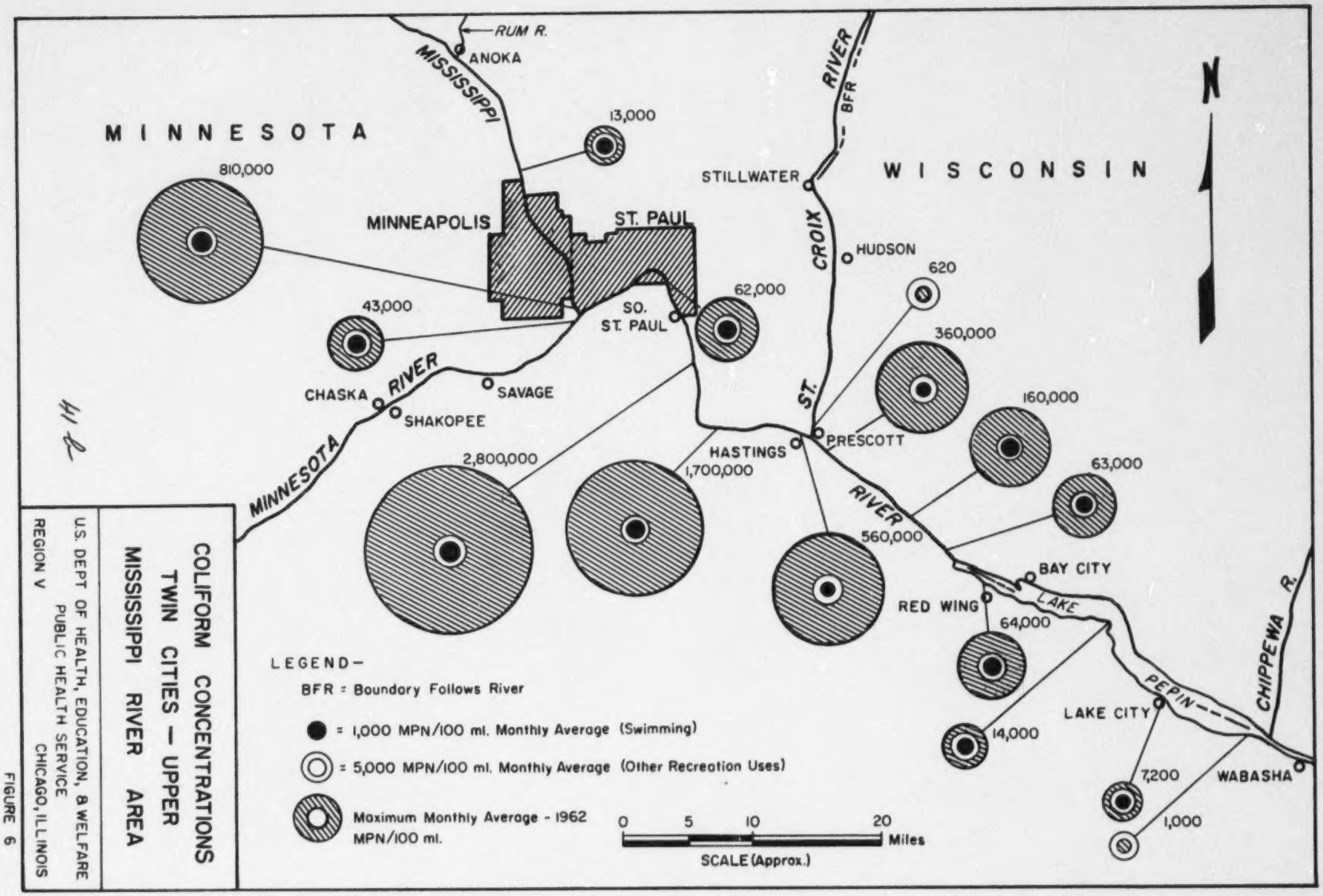
It might be pointed out that these presumptive coliform measurements are total counts and include all types, including non-fecal varieties. Mr. H. F. Clark, Research Branch Biologist, Division of Water Supply and Pollution Control, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, has reported on the efficacy of differential testing for fecal coliforms and fecal streptococci. On the basis of a 96% correlation as to the source of specific coliforms from the gut of warm blooded animals and a better than 99% correlation of fecal organisms with a fecal source, and the non-fecal organisms with the absence of any fecal source, any definitive stream survey should include three test procedures: the total coliform test, the fecal coliform test as a supplement to the total coliform test to be able to pinpoint the

GPO 807-096-6

coliforms that come from soil erosion, and the fecal streptococci test with a sufficient number of species identifications performed in certain specified samplings on the strain type or species type of streptococci to be able to indicate a possible source from which those streptococci were derived.

Included as a part of this report in the Appendix is a statement prepared by Mr. Clark concerning the "Bacteriological Examination of Stream Samples." The Minnesota Water Pollution Control Commission reports that differential testing for coliforms has been initiated during the past year as part of its water quality evaluation program.

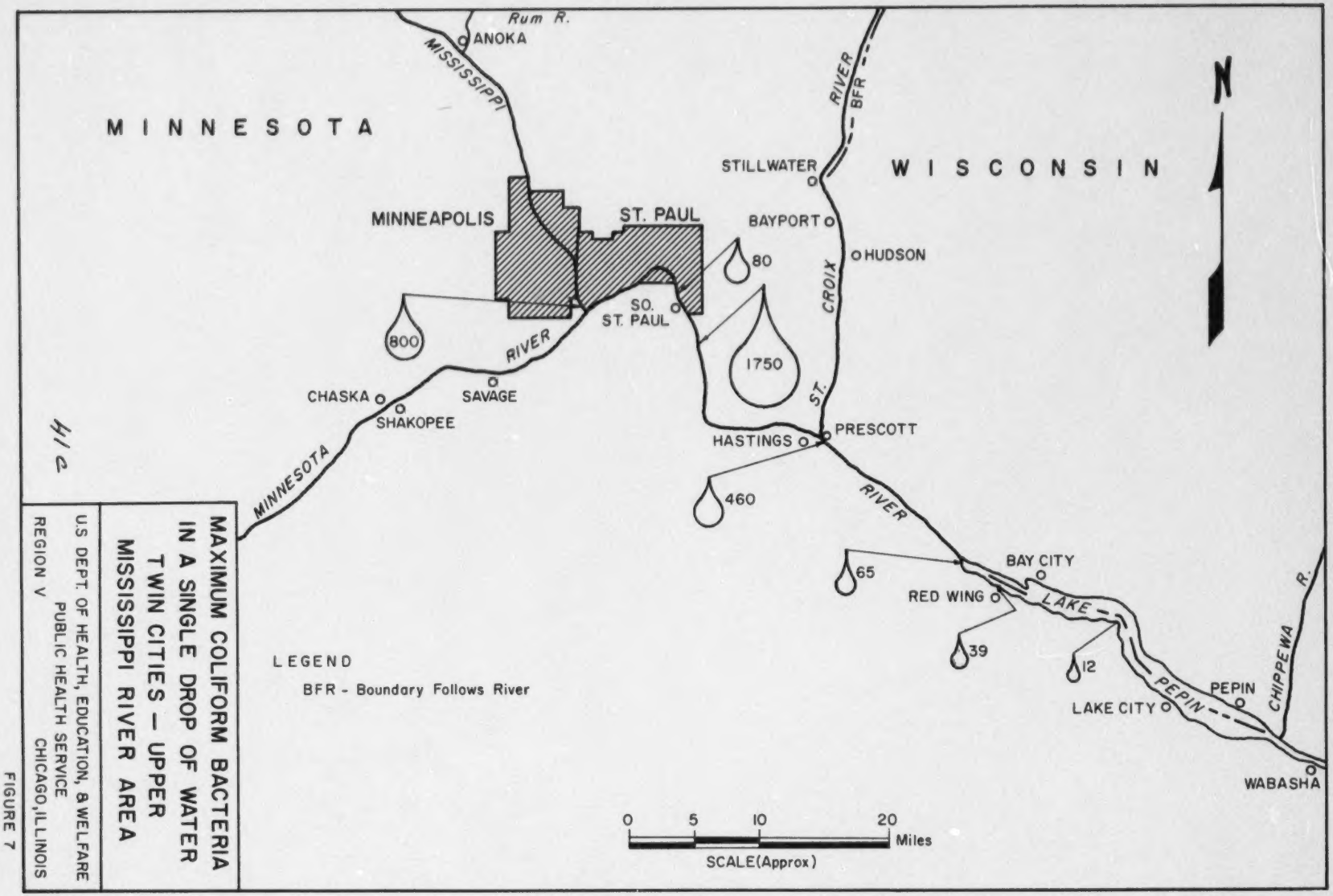
Although commendable progress has been made in sewage treatment in the entire Twin Cities Area, including the significant Minnesota and St. Croix Rivers, further improvements are needed to minimize the hazards of excessive bacterial contamination. The more serious problems indicated by available data are the high densities throughout much of the main stem of the Mississippi River and the Minnesota River which constitute a hazard to recreational uses including sport and commercial fishermen. Major needs for improvement include measures for reducing the effects of discharges of raw sewage from diversion structures on the collection system throughout the metropolitan area, more adequate disinfection at the Minneapolis-St. Paul Sanitary District treatment plant and the South St. Paul treatment plant, and the identification and control of other bacterial contributions throughout the area.



COLIFORM CONCENTRATIONS
TWIN CITIES — UPPER
MISSISSIPPI RIVER AREA

U.S. DEPT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
CHICAGO, ILLINOIS
REGION V

FIGURE 6



MAXIMUM COLIFORM BACTERIA IN A SINGLE DROP OF WATER
TWIN CITIES – UPPER MISSISSIPPI RIVER AREA

U.S. DEPT. OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION V
CHICAGO, ILLINOIS

FIGURE 7

FIVE-DAY BIOCHEMICAL OXYGEN DEMAND

The studies conducted by the Minnesota Department of Health in 1960-1961 and the definitive analysis of MSSD data by Professor George J. Schroepfer of the University of Minnesota outline the degrading effects of the Biochemical Oxygen Demand (five-day) on the Mississippi River as it passes through the Twin Cities metropolitan area to its juncture with the St. Croix River.

Using August, 1962, five-day BOD data and mean river flows supplied by the MSSD as an example, the average loading for that critical month increased from 59,500 pounds/day at Fridley above the Twin Cities to 63,000 pounds at the Fort Snelling Bridge above the Mississippi's confluence with the Minnesota River; to 98,000 pounds at the Robert St. Bridge, and 101,500 pounds immediately above the MSSD outfall.

The Minnesota River was a significant contributor to the overall five-day BOD loading of this stretch of the River with an average discharge of 26,100 pounds. Dissolved oxygen levels on the Minnesota River ranged from 0.4 mg/l to 20 mg/l, at the County Road 18 Bridge below Shakopee, Minnesota. Below the MSSD outfall the BOD loading averaged 305,000 pounds at River Mile 835.0 above South St. Paul. This high loading dropped rapidly to 234,000 pounds at the Inver Grove Bridge some five miles downstream and thence to 148,000 pounds at the Hastings Highway Bridge. The calculated average five-day BOD loading on the Mississippi River below its confluence with the St. Croix River for August, 1962 was 139,500 pounds. The high rate of early deoxygenation in the river

stretch immediately below the MSSD plant and South St. Paul reported by Professor Schroepfer in his studies is apparent.

The total five-day BOD from all sources of sewage is estimated to be approximately 228,180 pounds per day. Of this 225,940 pounds per day, or 99.1 percent, were discharged directly to the Mississippi River. The MSSD plant accounted for 209,000 pounds per day, or 91.6 percent. The South St. Paul Treatment Plant discharged an estimated 14,500 pounds per day, or 6.3 percent.

The survey by the Minnesota Department of Health in 1960-1961 reported a virtual total depletion of dissolved oxygen for a 7.5 mile stretch of the river from below the MSSD outfall to the vicinity of the Great Northern Oil Company barge slip. Data from the MSSD river sampling program for that period confirmed these conditions.

The pending expansion program to secondary treatment for the MSSD plant has been based principally on DO levels to be maintained in the Hastings Pool of the Mississippi River under varying flow conditions originally established to meet the requirements of the Minnesota State Board of Health in 1934. With some modification these have been interpreted by the MSSD to require: (a) maintenance of 2 ppm of DO at mean monthly discharges exceeded 90 percent of the time during the critical months of February and August; (b) maintenance of one ppm of DO at mean monthly discharges exceeded 99 percent of the time during the critical months of February and August, and (c) maintenance of a trace of DO during periods of minimum five-day discharges exceeded 99 percent of the time during the critical months of February and August.

Additionally, four ppm of dissolved oxygen would be maintained during periods of minimum five-day discharges exceeded 99 percent of the time during the critical months of February and August in the Mississippi River both above its confluence with the Minnesota River and below its confluence with the St. Croix River.

SUSPENDED SOLIDS AND SLUDGE DEPOSITS

The physical and nutritional changes effected by organic sludges of certain industrial or sewage origin may result in the formation of zones in a stream, characterized by different organism associations. A clean water zone may have a bottom composed of small and large stones. In this type of environment are found many different kinds of bottom-fish-food organisms, plankton, and fish. Fish nesting areas are numerous. The typical association of clean-water-dwelling animal species are immature caddisflies, stoneflies, mayflies, hellgrammites, gill-breathing snails, and pearl-button clams. Small-mouth black bass, sunfish, and various minnows abound. Numerous kinds of plankton are present. Thus in the unpolluted zone there is a great variety of animals and plants, but because of predation and competition for food and living space these are represented by few individuals.

In the zone of recent pollution, floating solids that become settleable blanket out light penetration and, on moving into the zone of active decomposition, settle to form sludge deposits over the entire bottom. Turbidities here are high. Only a few kinds of animals and

plants can survive on the soft, shifting blanket of sludge. Such organisms, isolated from many predators, form huge populations of individuals. Solids, in settling, flocculate floating small animals and plants out of water; thus these are scarce. The few animal forms that are adjusted to living in a sludge substrate are sludgeworms, some kinds of bloodworms, water sow-bugs, certain snails, and various leeches. Fish are absent or are scarce and prefer to form their nests elsewhere. Flowering water plants are absent, not being able to root in sludge deposits. Most algae are extremely scarce, being represented by dominating blue-greens that form gelatinous slimy coverings over the sludge in shallow marginal water.

Bottom deposit investigations are reported in the Minnesota Department of Health's "Investigation of the Mississippi River from the Mouth of the Rum River to the Mouth of the St. Crois River" (1960-1961) and the University of Minnesota's report to the MSSD, "Pollution and Recovery Characteristics of the Mississippi River" Volume I, Part Three, September, 1961. Sludge deposits are common for the entire distance of 21.2 miles from the MSSD plant outfall to the Hastings Dam.

These deposits were reported as ranging up to 4.5 feet in depth and varying in consistency from a thick black sticky mass to a sand-sludge mixture. The most active area in terms of sludge decomposition, as would be expected, was in the four miles below the MSSD outfall. These conditions originally surveyed in 1959 generally agreed with conditions found by the Department of Health in their 1961 investigations.

During these investigations, the river was reported as being highly colored with solids characteristic of packing house wastes in particular.

Reports on the biology of the river in terms of a qualitative evaluation of the aquatic environment were briefly described in the MSSD report for the section immediately above the MSSD outfall, the center of the river approximately 1.5 miles downstream from the MSSD outfall, and the west side of the river some three and one-half miles downstream from the MSSD outfall.

The presence of tubifex worms (a sludge worm) and various forms of small shell life were the only forms of aquatic flora and fauna reported.

Information on the biological character of the interstate waters of the Mississippi River as well as the Minnesota River is limited to the recent oil spill investigations by the scientists from the Robert A. Taft Sanitary Engineering Center. The effects of these spills are well documented with significant shore and bottom areas blanketed with the polymerized soya oil in the upper sections of Lake Pepin, in the Mississippi River, and in the Minnesota River as far back as Mankato, Minnesota.

A continuing assessment of the biological character of the river sludge deposits is needed for the entire river stretch under consideration. Identification of the industrial sources of both organic and inorganic solids should also be made, because of the lack of recent data in some cases.

OIL

It is difficult and impractical to measure oil in large streams and no quantitative data on oil in the waters of the Mississippi River are available. Evaluation of the oil pollution problem can be based only on reports of visual observations and on reported evidences of the effects of pollution.

One dramatic effect of oil pollution is its killing power on ducks. Death can come to ducks in several ways. The oil coats their feathers and they become waterlogged, lose their ability to fly, and may drown. Oil also breaks down the feathers' insulating capacity, and the ducks may freeze to death. Ducks covered with oil do not eat normally and may starve to death. They attempt to preen oil off their feathers, and they ingest toxic materials that cause their death.

This drama was played out during the winter of 1962-1963 as the result of two massive oil spills on the Minnesota River. An estimated 1,000,000 gallons of petroleum cutters oil from the Richards Oil Company at Savage, Minnesota (River Mile 12.0) and an estimated 2,500,000 gallons of crude soy bean oil from the Honeymead Plant at Mankato, Minnesota (River Mile 101) combined to coat the Minnesota and the Mississippi Rivers from Mankato downstream into Lake Pepin for a distance of about 130 miles. The oil moved with the ice break-up in late March and was coincident with the northward migration of the many thousands of ducks which use the Mississippi flyway. Approximately 3,000 birds were found dead or dying

and it was estimated that up to 10,000 ducks met untimely deaths as the result of this oily trap.

The polymerization of the soy oil resulted in the formation of spongy "blankets," or "ropes," which were either deposited on the beds of the rivers and lakes or were blown onto the shores. The beach at Bay City, Wisconsin in particular is still feeling the effects of this pollution.

The problem of accidental oil spills is a continuing one and major steps must be taken from both a legal and preventative control standpoint. Recent progress in this direction has been exemplified in the action of Governor Rolvaag and the Minnesota legislature in supplying legal tools to the Minnesota Water Pollution Control Commission with which to work on a program for control of spills.

ALGAE

Wastes containing nitrogen and phosphorus (fertilizers) pollute our waters and contribute to the increase of certain organism populations. Organism populations reach such magnitudes that water uses are interfered with and nuisances are created. Organisms that respond to such nutrients are certain floating and attached algae and rooted aquatic plants. If streams, lakes, and man-made impoundments continue to become enriched with wastes of industrial, municipal, and agricultural origin, biological nuisance problems that exist today will become intensified in many areas. Other areas that do not have them now can certainly expect them.

GPO 807-096-7

Inorganic and organic nutrients containing nitrogen and phosphorus are among the major factors that contribute to plant abundance including nuisance algal blooms. In modern waste treatment practices, dissolved inorganic or mineral constituents of municipal sewage and industrial wastes are removed only incidentally by sedimentation and oxidation. Also, certain organic materials are broken down with treatment to liberate inorganic nitrogen and phosphorus, thus making them more available as fertilizers for plant growth. Treatment plant effluents may actually contain more readily available nutritional (fertilizer) substrates than are found in raw sewage effluents.

It has been reported that if assets of inorganic nitrogen and phosphorus exceed 0.30 mg/l and 0.01 mg/l, respectively, in a lake at the start of the active growing season, a season with nuisance blooms could follow. This does not limit the possibility of algal growth to these nutrients, alone, since many other factors no doubt contribute to their development.

Within the intrastate sections of the Mississippi River above Hastings, Minnesota, the phosphorus concentrations increased from an average of 0.097 mg/l in the upper section, to 0.18 mg/l in the middle section, and 0.48 mg/l in the lower section. Total nitrogen levels within the same ranges averaged 0.70, 0.80, and 3.4 mg/l, respectively. As reported in the State of Minnesota 1960-1961 survey, each of these water quality indices increased four fold as the river passed through the

metropolitan complex.

Downstream, the Public Health Service's National Water Quality Network Station at the Red Wing Lock and Dam reported phosphate concentrations ranging from 0.5 mg/l to 0.8 mg/l during July and August, 1960 and 0.2 mg/l to 0.4 mg/l during August and September, 1961. Total nitrogen was not reported. However, ammonia nitrogen levels ranged from 0.0 mg/l to 0.2 mg/l in 1960 and 0.3 mg/l to 1.0 mg/l in 1961 for the same periods.

The present and future effects on the total water resource of the area should be determined with respect to these important water quality indices which may contribute or trigger the growth of nuisance blooms of algae.

TASTES AND ODORS

Over the years, a continuing complaint reaching the Minnesota Department of Conservation has been the off-tastes of fish caught in various stretches of the Mississippi River in the Twin Cities area. These reports have mainly concerned fish taken in the reach above the Hastings Dam with occasional complaints coming from as far south as Red Wing and Lake Pepin.

A wide variety of substances has been suggested as agents producing tastes and odors in water and off-flavor in fish flesh. The better known compounds include phenols, mercaptans, and other complex aromatic organic substances. Not to be dismissed, though, is the taste and odor producing

capability of many algal forms.

Within the area under study and particularly in the reach above the Hastings Dam, phenol concentrations of 49 ppb in the River were reported at River Mile 829.4. A phenol concentration of 65 ppb in an outfall creek was also reported by the Minnesota Department of Health at River Mile 818.1. The average concentration of phenols in the stretch of the river from River Mile 830.3 to River Mile 813.6 was reported as 24 ppb in the State of Minnesota's report of survey for 1960-1961. No information on phenol levels is available for the interstate section of the Mississippi River below Prescott, Wisconsin.

By way of comparison, the International Joint Commission's recommended standard for phenols or phenol equivalents in the international waters of the Detroit River limit the concentration to a monthly average of 2 ppb with a maximum not to exceed 5.0 ppb after initial dilution of the wastes. A similar standard has been recommended in the Bi-State Agency 1954 Report to the States of Missouri and Illinois for the Mississippi River in the St. Louis Metropolitan Area. The phenol concentration limits set in the classification program of the Minnesota Water Pollution Control Commission, range from 10 ppb above the MSSD outfall to 100 ppb in the River stretch below the MSSD plant to the Mississippi River's confluence with the St. Croix River.

Evaluations of taste and odor problems in the Mississippi River in the Twin Cities area have been attempted in the past, but no formal report was developed and the results were apparently inconclusive.

The need for an intensive review of this water quality problem is necessary in the development of an overall water quality control program.

PESTICIDES

Recent controversies associated with the programs for the control of the fire ant, the spruce bud worm, the gypsy moth, other forest insects, and extensive pesticidal application on food crops have focused attention on the problems of those interested in the preservation of the aquatic habitat. Most pesticides are toxic to aquatic life; some are highly toxic (e.g., 0.6 pounds of Endrin in 120 million gallons of water will kill bluegill sunfish); some accumulate in the fat and flesh of organisms and in bottom muds. Their use has resulted in the killing of fish and waterfowl, as well as invertebrates such as crabs, crayfish, and aquatic insects that are important in food chains.

Use of pesticides by the aquatic biologist at times has been an important aspect of lake and stream management; such use has been directed toward the control of nuisance midge, mayfly, and mosquito populations, undesirable algae and aquatic weed growths, the sea lampreys, and stunted or undesirable fish populations. Pesticides exhibit tremendous variation in their impact upon the aquatic community; great variation is also shown in the susceptibility of the many kinds of aquatic invertebrates important in fish and waterfowl food chains within that community. Various additives such as solvents, wetting agents, and dilutents tend to decrease the hazards to birds and animals and increase the toxicity to aquatic organisms.

The kinds of animals associated with the pesticide-treated habitat, and their activities within the treated area are important factors in governing the hazards of the application. The season of the year greatly influences the effect of the pesticide because of the migration, hibernation, and life cycle of the aquatic organism, waterfowl, and other wildlife. The recovery of an affected area depends upon many factors among which are the proximity of similar habitats, the migratory tendency and range of the animals, and the number of generations per year.

Pesticides must be considered individually rather than collectively, and toxicity problems must be balanced between the beneficial and harmful effects of a proposed application upon the aquatic environment. To do this necessitates a knowledge of the toxicity and associated hazards of the control agent. Usage must be governed by rigid controls, and adequate safeguards must be installed against "careless use," which has so often been the chief cause of unwarranted aquatic mortalities. Estimates on total poundage of the various pesticides, weedicides and other exotic control compounds used in the Twin Cities area are not available. Effects on water quality in the Minnesota, Mississippi, and St. Croix Rivers from these agents have yet to be assessed.

TEMPERATURE

The pollutional effect of temperature increases on aquatic life in natural waters has long been overlooked or ignored. A subtle effect is illustrated by the decrease in solubility of oxygen in fresh water. Under a pressure of 760 mm of mercury at sea level and 32°F, it is 14.62 ppm,

at 68°F, it is 9.17 ppm, and at 86°F it is 7.63 ppm. Thus, heat alone can deny aquatic life the necessary oxygen reserves. Where a putrescible waste creates a high biochemical oxygen demand and takes additional oxygen from the stream, increased temperatures are dangerous as they may be related to the depletion of dissolved oxygen to suffocating levels for aquatic life.

Another subtle effect of temperature increase is reflected, on occasion, in the increased toxicity of certain chemicals to aquatic forms. For example, high temperatures increase the toxicity of rotenone to fish. Brown trout die much more rapidly at 70°F than they do at 55°F, the time being about 15 and 70 minutes, respectively, with a 0.40 ppm dosage. With dosages of 0.20 ppm they die in about 22 minutes at 70°F, and in 100 minutes at 55°F.

In field investigations involving industrial wastes on large streams, it may be difficult to relate detrimental effects of temperature, i.e., heat pollution, to specific aquatic organisms. High temperatures may adversely affect the over-all biota by eliminating many organisms, but in doing so, allow a few, such as certain heat resistant blue-green, scum forming nuisance algae, to become dominant.

Gross limits of temperature to which most warm-water fish are subjected in natural bodies of water are somewhere between 32°F to 95°F. The standards of water quality adopted by the Minnesota Water Pollution Commission relative to thermal discharge state that between the Rum River and the Minneapolis-St. Paul Sanitary District Plant the discharge of wastes shall be controlled so that the heat content of such discharge

does not raise the river temperature above 93°F at any point after reasonable dilution. In the stretch between the MSSD plant and the mouth of the St. Croix River, the standard states that the discharge shall be controlled so that the heat content of the wastes will not raise the temperature of the river high enough to be directly injurious to fish life, or substantially interfere with or affect adversely other established uses.

Current knowledge does not permit a precise statement regarding the effects of varying temperature levels on the over-all biota of a stream. In general, in most temperate-zone streams of low gradient, large reaches should not exceed 86°F for prolonged periods; headwater streams will probably have an upper limit of from 72° to 77°F for extended periods of time. Additional research is likely to lower rather than raise these limits.

Temperature effects resulting from both present and future thermal loads on the Mississippi and Minnesota Rivers' waste assimilation capacities in terms of dissolved oxygen during critical periods of flow have been analyzed by the University of Minnesota for the MSSD. However, the long term effects of high river water temperatures on the biota of the streams have not been fully evaluated.

In addition to the effects of temperature on the biota of the stream, another principal effect of thermal discharges is the possible curtailment or limitations placed on the electrical generating plants in the area as a result of the loss of cooling capacity in the waters.

This aspect has been studied in detail by the Sanitary Engineering Division of the University of Minnesota for the MSSD and is currently being investigated by the Northern States Power Company in light of the recently adopted standards of water quality on the Mississippi.

AMMONIA, pH, ALKALINITY, HARDNESS, A.B.S.

The presence of ammonia nitrogen in a stream is notable for several reasons. Of particular concern in terms of water quality, are the changes that occur in streams receiving waste discharges which may contain varying amounts of nitrite, nitrate, ammonia, and organically bound nitrogen. The effect of these materials on the stream is complicated by the condition of the stream receiving the effluent. Streams already depleted in DO will utilize oxygen in nitrate, thereby converting the nitrate to ammonia, nitrogen gas and proteinaceous matter. Streams with sufficient oxygen resources will continue the oxidation or assimilation of ammonia to proteinaceous material, nitrogen gas, nitrite and nitrate. Oxidizeable nitrogen becomes a part of the biochemical oxygen demand exerted on the stream. It is known that ammonia is a substance toxic to many forms of aquatic life at high levels and under alkaline conditions. Results of the survey of 1960 and 1961 by the Minnesota Department of Health indicate some high ammonia values and no pH values in the acidity range. However, the data are too limited for the drawing of conclusions at this time and should have further study.

The test for A.B.S. is a measure of the large, anionic-type molecules

GPO 807-096-8

which, in streams, are representative of the synthetic organic detergents now contaminating many surface and ground waters. A.B.S. is that portion of a common household or industrial cleaning compound that imparts foam and reduces surface tension to aid in the removal of dirt particles by the cleaning compound. A.B.S. is believed to be nontoxic to man in the concentrations found in contaminated waters; but it produces unsightly, persistent foams in streams at points of agitation or discharge over dams. Although no data are available on the A.B.S. content of the river, reports have been received of waves of suds several feet high generated by the action of barge tows leaving terminals.

The Minnesota Health Department, in collecting samples during the 1960-1961 investigations, reported determinations of alkalinity and hardness on some of the samples. Alkalinity expressed usually as $CaCO_3$ is a measure of the neutralization reserve present in a water, or the extent to which the water can resist a change from an alkaline to an acid condition upon addition of acidic chemicals. Hardness also expressed as $CaCO_3$ is not only a measure of the soap consuming property, but is also of importance in the treatment of boiler waters, where it is one of the most important factors.

The data collected by the State indicate some significant changes in both alkalinity and hardness between adjacent stations sampled the same day. Their data are summarized on the next page:

Stations	Change in Alkalinity mg/l as $CaCO_3$	Change in Total Hardness mg/l as $CaCO_3$
M-6.2 to M-4.9	150 to 350	
M-0.1 to M+0.1	230 to 170	
M+3.1 to M+3.2	160 to 220	180 to 440
M+4.6 to M+5.2		170 to 260
M+5.6 to M+5.8	120 to 220	110 to 320
M+7.5 to M+7.9	160 to 270	180 to 300

It is possible that the heavy volumes of ground water used for air conditioning within the metropolitan area contribute to the increases in alkalinity and hardness as noted in this table.

CONTROL ACTIVITIES OF STATE AGENCIES

The Wisconsin Committee on Water Pollution and the Minnesota Water Pollution Control Commission adopted a joint resolution concerning waste treatment requirements for interstate waters of the St. Croix, and Upper Mississippi Rivers and their tributaries in 1953. The resolution provided that "for treatment of sewage and for industrial wastes shall provide at least effective sedimentation or equivalent, substantially complete removal of floating solids or liquids, and reduction of toxic materials to less than lethal limits for aquatic life, with the understanding that additional or special type treatment be required in those areas where water uses so dictate." The two State water pollution control agencies have worked with municipalities and industries to accomplish the objectives of the joint resolution.

Though the bi-state agreement between the official pollution control agencies of Minnesota and Wisconsin requires a minimum of primary treatment on the interstate stretch of the Mississippi River, the City of Red Wing, Minnesota, in an independent action, constructed secondary treatment facilities for its wastes. The protection of recreational water uses in the downstream areas of Lake Pepin was recognized by this action.

Both States have effective water pollution control laws. Within the area under consideration, the Wisconsin Committee on Water Pollution can point to waste treatment facilities for every sewered community. Similarly, the Minnesota Water Pollution Control Commission has received compliance from each sewered community on its portion of the interstate section of the Mississippi and St. Croix Rivers.

Each State has used the grant provisions of the Federal Water Pollution Control Act for sewage plant construction effectively. Ten plants involving a total eligible cost of $4,309,878 have been granted $1,203,513 in Federal funds.

Of primary importance in the control of water quality in this area has been the adoption in March, 1963, of classification standards for the Mississippi River and its tributaries in the stretch from the Rum River to Hastings, Minnesota. Essentially, the classification program provides for three zones of varying use and quality. These range from the highest uses, including public water supply and swimming, in the zone from the Rum River to St. Anthony Falls to waters for limited recreational, industrial and commercial use in the zone from St. Anthony Falls to the outfall of the MSSD plant, and finally to the third zone from the MSSD plant outfall to the Hastings Dam which allows use for

industrial process and general cooling, stock watering, restricted irrigation, disposal of treated wastes, fish survival and very limited recreational activities.

Standards of quality are set for each zone. Dissolved oxygen, for example, has an upper limit that ranges from a 5 mg/l requirement in the upper zone to a 4 mg/l level in the middle zone, and finally to a 2 mg/l standard for the lower zone. Each is based on the monthly average flow which is exceeded by 90% of the monthly average flows of record for the month of August or February, whichever is lower. The development of this intrastate section of the Mississippi as well as the Minnesota River within the Twin Cities area will be dictated by the dissolved oxygen levels and other standards required in the classification program.

The Minneapolis-St. Paul Sanitary District is the major waste contributor in the area. This agency has collected a vast store of water quality information for significant stretches of the Mississippi River since 1926. A five year project sponsored by the MSSD and conducted by Professor George J. Schroepfer of the Sanitary Engineering Division, University of Minnesota, was completed in 1961. This intensive study assessed the capabilities of the Mississippi River to assimilate the discharge of present and expected waste loads in the critical stretch below Minneapolis-St. Paul. Design of the secondary treatment facilities, which are now under construction, was based upon the findings of Professor Schroepfer's report and the 1967 River Standards Classification of Minnesota Water Pollution Control Commission.

WISCONSIN
RIVER
MISSISSIPPI
RIVER
ANOKA
ST. CROIX
COON RAPIDS DAM
ST. ANTHONY FALLS LOCK & DAM
STILLWATER
BAYPORT
HUDSON
MINNEAPOLIS
ST. PAUL
SO. ST. PAUL
CHASKA
SHAKOPEE
SAVAGE
PRESCOTT
HASTINGS
RED WING
LAKE CITY
MINNESOTA
N
LOCATION MAP
TWIN CITIES – UPPER
MISSISSIPPI RIVER AREA

A'PENDIX

BACTERIOLOGICAL EXAMINATION OF STREAM SAMPLES*

Microbiology
Water Supply and Pollution Control Research
Robert A. Taft Sanitary Engineering Center
U.S. Department of Health, Education and Welfare
Public Health Service
Cincinnati, Ohio

Introduction to Methodology

The Standard tests for the coliform group described in Standard Methods for the Examination of Water and Wastewater, 11th edition, 1960 (1) are designed specifically for the quantitative determination of the coliform group. The coliform group includes all the aerobic and facultative anaerobic, non-spore-producing, gram-negative rods which ferment lactose with gas production within 48 hours at 35 (plus or minus 0.5)°C. The standard tests are:

1. Presumptive Test (based on gas production from lactose) in which a negative reaction excludes the coliform group and a positive test indicates that coliform bacteria may be present.
2. Confirmed Test which demonstrates gas production from lactose in the presence of bile salts and brilliant

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*Statement prepared by Mr. Harold F. Clark, Microbiologist, In Charge of Water Borne and Studies, Research Branch, Division of Water Supply and Pollution Control, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio.

green or the production of nucleated (with or without sheen) or opaque, mucoid, unncleated colonies confirms the presence of the coliform group, using Eosin Methylene blue agar or Endo agar plates.

3. Completed Test in which the coliform bacteria is isolated in pure culture and demonstrated to produce gas from lactose as well as consisting of gram-negative rods consistent with the morphology of the coliform group. This is the coliform reference test for the multiple tube procedure in Standard Methods (B.3. page 499).

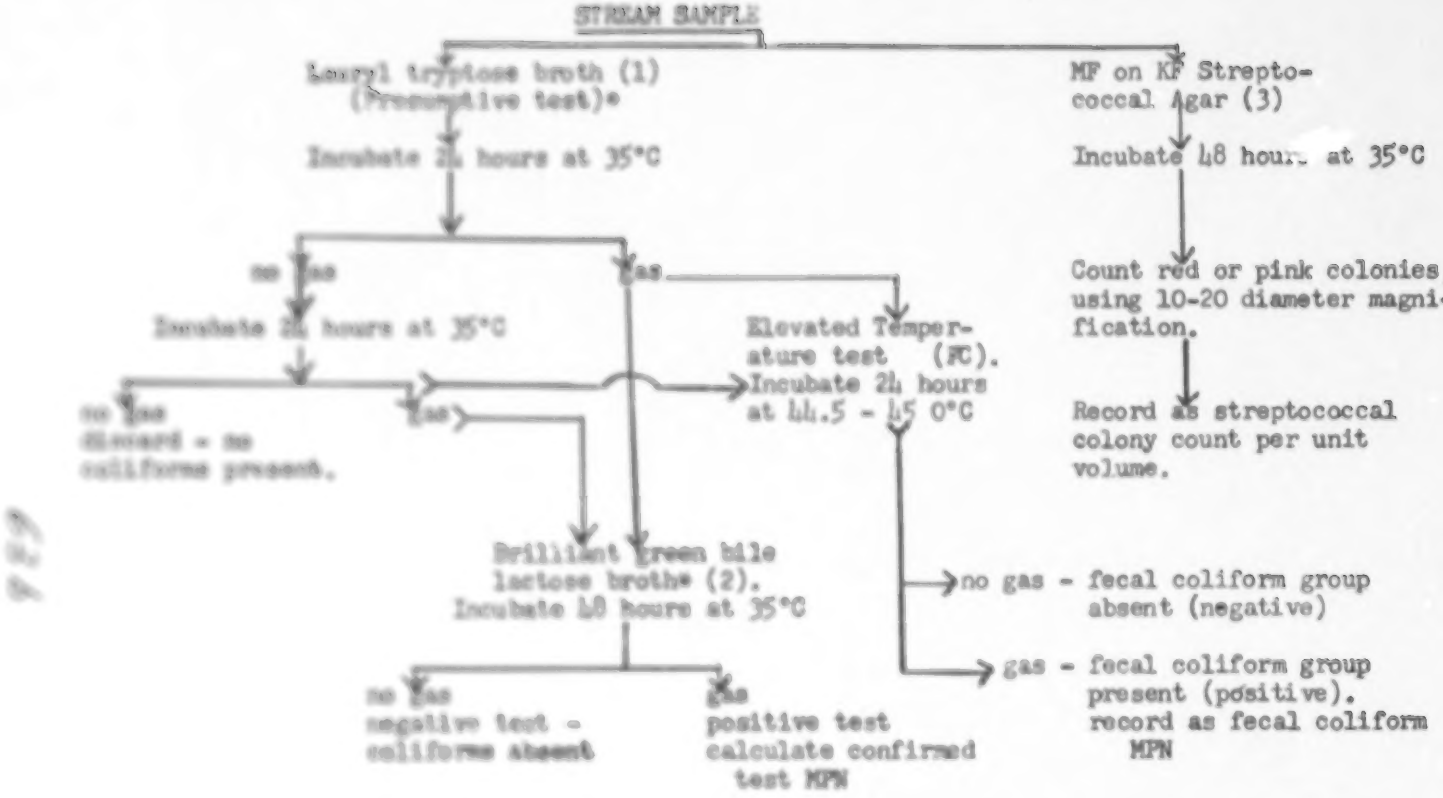
4. Membrane Filter Technique consisting of filtration of the sample through a membrane filter, cultivation of the coliform colonies on the filter surface using the Standard Methods (12. page 488) M-Endo Medium and counting coliform colonies for a "coliform colonies" count.

The above Standard Methods procedures, by not distinguishing between the various types of coliform bacteria composing the coliform group, yield no information as to their possible source or origin. A group of tentative differential tests is described but no suggestions are given as to their interpretation other than such procedures seldom give sufficient information to justify the labor and time required for the procedures. Presence or absence of the coliform group is all that is necessary in the bacterial examination of a potable water and the standard tests are adequate for this purpose (2).

The objectives in the bacteriological investigation of untreated surface waters, such as used in a stream survey, must go beyond the procedures described in Standard Methods. Bacteriological objectives include the quantitative estimation of all indicator microorganisms of pollution so that as much information as to the probable sources and significance can be collected as is consistent with accepted bacteriological research methods and practices.

In the accomplishment of these objectives, it is necessary to use newer research methods which are beyond the scope and objectives of the procedures in Standard Methods. The testing methods include the elevated temperature test which indicates the fecal or non-fecal origin of coliform bacteria and the streptococcal method as an indicator of pollution. Both of the procedures and their interpretation have been established by detailed research investigations on the distribution of indicator microorganisms in feces as well as in other environments (3, 4, 5, 6, 7, 8).

Bacteriological procedures used in the examination of stream samples are shown in the following schematic diagram. Procedures which are marked with an asterisk are described in Standard Methods while unmarked methods represent tests not described and are the product of recent research studies.



* Indicates procedure described as standard test in Standard Methods for the Examination of Water and Wastewater, 11th ed. (1960).

(1). Lactose broth may be substituted for lauryl tryptose broth.
(2). Eosin Methylene blue or Endo agar may be substituted for the brilliant green bile lactose broth.
(3). The KF Agar pour plate count may be used interchangeably with the MF colony counting technique.

Discussion of Tests

Stream samples are collected and examined for the coliform group according to the procedures described in Standard Methods. These procedures include the use of lauryl tryptose broth for a screening test and confirmation of the presumptive positive tubes in brilliant green bile lactose broth. This is considered preferable to the lactose broth option in the presumptive test and the Endo or Eosin-Methylene Blue plate options in the confirmed procedure. The "Confirmed Test" enumerates the coliform group in the sample but yields no information as to probable source, such being derived from feces, soil, plants, etc.

Elevated Temperature Test (EC)

at 45°C

The procedure for the Elevated Temperature Test consists of the following steps:

1. Transfer a loop of broth from the positive presumptive tube to an EC broth tube containing an inverted vial to indicate gas production.
2. Place the inoculated EC tube, within less than 30 minutes after planting, in a water bath at 44.5 - 45.0°C.
3. Incubate at 44.5 - 45.0°C for 24 (plus or minus 2) hours in water bath.
4. Record the presence or absence of gas in the inverted vial.

The presence of gas in the inverted vial is a positive reaction indicating that coliforms derived from the gut of warm-blooded animals

(fecal coliforms) were present in the sample. Absence of gas indicates the absence of fecal coliforms in the tube since the members of the coliform group derived from non-fecal sources generally fail to produce gas in this medium at 44.5 - 45.0°C. The fecal coliform density is calculated on the number of positive and negative tubes in the series in the same manner as for the coliform group MPN.

Streptococcal Colony Count

Streptococcal enumerations are made by the membrane filter technique using KF Streptococcus Agar as nutrient substrates. The medium is prepared as follows:

1. Mix 7.64 grams of KF Streptococcus Agar (Difco 0496) with 100 ml sterile distilled water in a sterile flask.
2. Place the flask containing the mixture in a boiling water bath to dissolve the medium containing the agar.
3. After solution is complete, continue heating in the boiling water bath for five (5) minutes.
4. Cool medium to between 50 - 60°C.
5. Add one (1) ml of sterile aqueous solution of one (1) per cent TTC (triphenyl-tetrazolium chloride)* solution and mix.
6. Pour from 5 - 8 ml of melted medium in each sterile plastic petri dish (Falcon No. 705012) and replace lid until medium hardens.

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* 2,3,5-triphenyl-tetrazolium chloride No. 6711, Eastman Organic Chemicals, is recommended. Do not autoclave solutions of this compound.

The medium is ready for immediate use or may be used at any time within 30 days, provided it is stored in a dark place and no evaporation has occurred during storage.

The procedure for the test consists of:

1. Filter an appropriate quantity of sample through the membrane filter.
2. Place Filter on KF Streptococcus Agar, grid side up, using care to have no air bubbles between the membrane filter and agar surface.
3. Incubate at 35°C for 48 hours (up to 72 hours is permissible).
4. Count all red or pink colonies, using a magnification of 10 - 20 diameters. Orange, yellow, white or other colonies with other colors, except red or pink, should not be counted since such types have not been observed in fecal examination.
5. Calculate count per unit volume as streptococcal colony count per unit (usualy 100 ml or 1 ml) volume.

The group of streptococci which meet the above definition are always found in feces and has little or no ability to produce after-growth in the stream. They arepresent in greater numbers than the coliform group in the feces of cat domestic animals, while the coliform group outnumber the streptococci in human excreta.

Fecal streptococci, likethe fecal coliform group, is interpreted to indicate fecal pollution. As the numbers of the indicators increases, the quantity of fecal pollutionincreases. However, each should be considered as an independent indicator of pollution. Survival rates

of each group vary under any specific environment and may vary greatly from environment to environment. Conditions may exist where one or the other indicator may die at a greatly accelerated rate.

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